DOCUMENT RESUME

ED 207 797 SE 035 483

AUTHOR	Hart, Richard A.
TITLE	A Manual of Mosquito Control Projects and Committee Assignments for 4-H and Scouts Biology Class Projects, Organized Community Service Programs, and Individuals Interested in Environmental Management.
INSTITUTION	Environmental Protection Agency, Denver, Colo.; Northwest Missouri State Univ., Maryville.
PUB DATE	Jun 80
NOTE	124p.; Contains occasional light and broken type.
AVAILABLE FROM	Environmental Protection Agency, Region VIII, 1860 Lincoln St., Denver, CO 80295 (free while supply lasts).
EDRS PRICE	MF01/PC05 Plus Postage.
DESCRIPTORS	Biology; *College Science; Community Programs; *Entomology; Environmental Education; Higher Education; Mathematics Education; *Public Health; Science Education; Secondary Education; *Secondary School Science; Statistics; *Student Projects
IDENTIFIERS	Biological Control; *Mosquitoes; *Pest Control

ABSTRACT

The mosquito control projects presented in this manual were prepared from an educational viewpoint and are intended for use by students in 4-H and Scouts and as a supplement to high school and college biology course work. The major emphasis of the projects is on integrated pest management, an approach utilizing cost-effective control methods which minimize environmental and health risks. Projects are organized into three sections: (1) "Getting Organized Projects," which are primarily educational or recreational and when taken collectively contribute toward reducing the numbers of mosquitoes; (2) "Control Projects," including map making, breeding site location and plotting, and collecting and identifying flying mosquitoes; and (3) "Research Projects," fostering the development of better control methods for local conditions by emphasizing the sampling of mosquito populations in such a way that meaningful descriptions and predictions can be made of the effects of control methods. (Author/JN)

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Colorado, Montana,
North Dakota, South Dakota,
Utah, Wyoming

EPA

ED207797

Integrated Pest Management of Mosquitoes

Mosquito Control Projects

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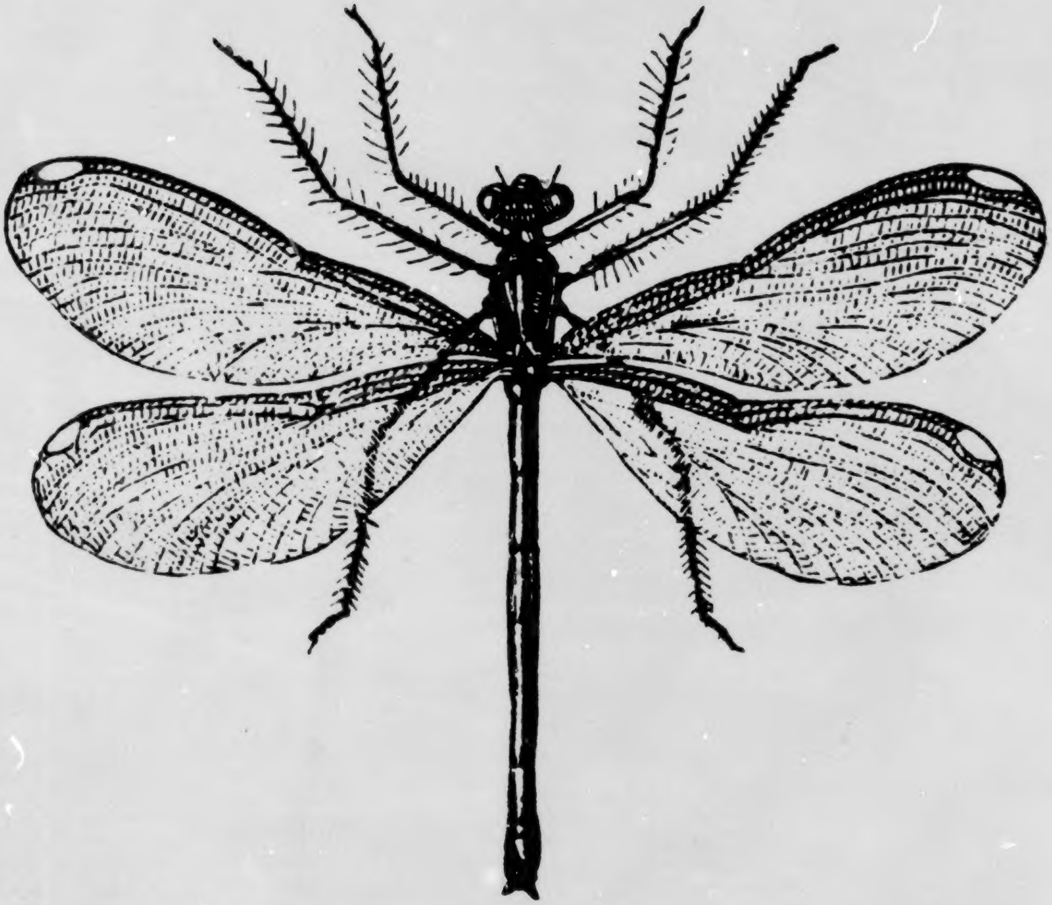

SE 035 483

Cover Illustration: The Mosquito-Hawk
Order: Odonata
Family: Calopterygidae
Species: *Calyopteryx apicalis*

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by
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I INTEGRATED PEST MANAGEMENT OF MOSQUITOES IN REGION VIII

II BACKGROUND

The main objectives of integrated pest management (IPM) include the use of cost effective control methods that are the most appropriate with respect to environmental and human health risks. Implementation of IPM principles through state systems should reduce the over use and misuse of pesticides for mosquito control. The states in Region VIII contain a full range of organization from the highly integrated state system in Utah to isolated, sporadic, community programs. Twenty-seven mosquito pest species live in the region.

III EPA ROLE/ACTION

An analysis of mosquito control operations at the state and at the control district level was started during the summer of 1978 to determine the role the EPA could play in the IPM of mosquitoes. Mature organized districts are practical models of IPM principles. This includes the safe and effective use of pesticides. Other communities must find ways to emulate these districts without the benefit of comparable funding and staffing. Specifically:

1. The time and cost of obtaining and using management information (accurate, unbiased, information) needed for communities to develop an optimum IPM program must be reduced if urban IPM is to replace routine adulticiding operations of questionable effectiveness that are consistent with current product labeling.

2. Further development of present state systems is needed to integrate educational (university and extension), regulatory (public health and agriculture), and local control operations, especially in the training of summer employees and in the supervision of programs in small communities.

The functional format of a project manual was selected to integrate a wealth of information and expertise in each state. A mosquito control project manual was completed for teenagers in 4-H and Scouts and as a supplement to high school and college course work. These people and their sponsors can assist communities in developing the IPM information required for mosquito control operations and for effective public education. The projects are prepared from an educational point of view; however, when taken together, they are the basis of an integrated pest management program for mosquito control. The projects can be used as job, as well as classroom, assignments. This report contains the corrected text for the manual after being submitted to twenty-five reviewers.

June 1980 Richard A. Hart, PhD

A
Manual
of
Mosquito Control Projects
and
Committee Assignments
for
4-H and Scouts
Biology Class Projects
Organized Community Service Programs
and
Individuals Interested in Environmental Management

1980

Richard A. Hart

Environmental Protection Agency, Region VIII, Denver, CO 80295
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Acknowledgments

This manual is the result of a number of experiences and opportunities:

1. Several years of teaching biology courses with projects that:
    - a. Divided the work into short meaningful steps.
    - b. Defined the problems needing solution.
    - c. Suggested answers and often resolved these problems.

2. Simplifying statistical calculations so students could:
    - a. Include the analysis of variance in their research designs.
    - b. Extract conclusions with a degree of confidence from large tables of numbers such as mosquito counts.
    - c. Read and interpret current biological literature.

3. A two year assignment with the Environmental Protection Agency, Region VIII, allowed time to travel and to collect both mosquitoes and the advice of mosquito managers in the states of Colorado, Montana, North Dakota, South Dakota, Wyoming and Utah.

4. Numerous telephone calls received in the Denver EPA office further impressed the need for a "do-it-yourself" manual for the community that wanted to do something about their mosquitoes but lacked funds to hire what they considered needed to be done.

5. Every community has people, including students, teachers, and clubs, in need of worthwhile projects.

A separate identification of the part each person played in shaping the manual cannot be made. Their names are listed on the following page of contributors. Special thanks are due the officials charged with mosquito control in each of the states, the officers of the American Mosquito Control Association and the mosquito managers in the Utah Mosquito Abatement Association.

The Intergovernmental Personnel Act (IPA) assigneeship to work on the Colorado Pesticide Applicator Certification Program was negotiated by Dr. George English, Vice President of Academic Affairs, Northwest Missouri State University and DeeWitt Baulch, Chief of the Program Support Section, Toxic Substances Branch, Air and Hazardous Materials Division, Environmental Protection Agency, Region VIII, who also supervised support services. (I was an IPA working on IPM for the EPA!) A note of appreciation also to my fellow Biology Department members for adjusting their schedules a second time.

A very special thanks to a family of three teenagers who were willing to change schools (Jeff, for his Senior year; James, his Sophomore and Junior years; and Mary-Louise, the 6th and 7th grade) and Margaret, their mother, who managed to keep the bills paid and the family cared for under four different work and school schedules that started at 4:15 am and ended at 2:00 am. They were also diligent mosquito collectors.

Contributors

Colorado. Ted Davis, Dept of Health; George Ek, Dept of Education; William Hantsbarger, CSU; Kenneth Conright, Tri-County District Health Dept; Billy Crockett, City and County of Denver; Cliff Myers, Jefferson County Health Dept, Barb Steinmeyer, Westminster; Kate McGuinness and Mark Randle, Paonia; Larry Kramer, Barr Lake State Park.

North Dakota. Albin Anderson, NDSU; Kenneth Tardif, Dept of Health; and Patricia Onufray, Williston.

South Dakota. Wayne Berndt and Ben Kantack, Extension; Dale Gillettee, Belle Fourche; Larry Holland, Watertown; Dan Ostrander, Aberdeen; and Jerry Wagner, Brookings.

Montana. Van Jamison and Kenneth Quickenden, Dept of Health and Environmental Sciences.

Wyoming. Everett Spackman, Extension.

Utah: Lewis Nielsen, Un of Utah; Reed Roberts, Extension; Wanless Southwick, Dept of Health; Glen Collett, Salt Lake City MAD; Steve Collett, Jay Graham, and Bettina Rosay, South Salt Lake County MAD; Steve Romney, Uintah County MAD; Elmer Kingsford, Logan County MAD; and Russell Snaith, Jr., Duchesne County MAD.

American Mosquito Control Association. Thomas Mulhern, Executive Secretary; W. Donald Murray, Delta VCD, CA; Glenn Stokes, Jefferson Parish MCD, LA.

Center for Disease Control. Carl Mitchell, Fort Collins, and Jack Stanley, Atlanta.

Aerial Photography Field Office (ASCS). Lola Britton, Salt Lake City.

Bureau of Land Management. Andy Senti, Denver.

Environmental Protection Agency. DeeWitt Baulch, Duane Bird Bear, Dallas Miller, Ed Stearns, Denver; and Ed Johnson and Charles Reese, Washington, DC.

And to all those who shared their experiences in the field, by phone, at meetings, and during training sessions, a sincere thank you. You quickly taught me practical mosquito cntrol is far more than the biology of mosquitoes. The management secret in each community is how to strike a balance between the pest population and the funding over public expectations.

The Projects

The first projects are detailed and specific. They are to get you going with a minimum of lost motion. After learning about mosquitoes and your community or study site, the projects emphasize decision making. These projects list the important factors to consider and then give examples. You can do an example or design your own project.

Designing your own projects is important. In this way you will be adapting mosquito control options to the specific conditions in your unique community. You will also be learning how to recognize what is a problem and what is not. Actions recommended should relieve a problem without creating another. This requires careful observation of all relevant factors: mosquitoes, breeding sites, people, and human activities.

The projects are first presented without regard for the variation between samples. When the need for repetitive measurements arises (as the basis for predictions and descriptions with a known degree of reliability), Part III has projects to demonstrate simple statistical methods. These methods can then be used in any of the measuring, sampling, collecting projects. With an appreciation of variance, a product of the random creative-destructive force, you are ready to assist in the scientific management of pest mosquitoes. It may even improve your grades on true-false and multiple choice tests.

Modify and add to the projects in this manual as your work progresses. At the community level, your work will turn it into a management manual for the specific species, breeding sites and pest problems in your community. The single page format was selected for ease in adding pages and in duplicating pages for group assignments.

As the projects are primarily concerned with the methods used to obtain needed facts for mosquito control in a community (breeding sites, pest species, and control options), they are usable by any community. The taxonomic and other specific examples based on the states in Region VIII can be used as models for additional projects in other states.

PRODUCT DISCLAIMER: Brand and company names are used for improved readability. Any equivalent item will do as well.

Mosquito Control Projects

Part I. Getting Organized Projects

Individual projects are primarily educational or recreational, however, in conjunction with a control program or taken collectively they also make a contribution toward reducing the number of nuisance and disease carrying mosquitoes. It is therefore important to know where your project fits into the needs of the entire community in which you live.

Part II. Control Projects

The core activities in mosquito management are map making, breeding site location and plotting, and the collection and identification of flying mosquitoes. Then comes the wrangle over what is the real problem, to what extent control measures are needed, of what kinds, and how to distribute the cost among those who benefit from the control program. There are outdoor projects and projects that require polling, writing, speaking and mediating.

Part III. Research Projects

Research projects can help develop better control methods for local conditions. The emphasis is on sampling mosquito populations in such a way that meaningful descriptions and predictions can be made of the effects of control methods. Good records become a research project in themselves over the years.

MOSQUITO CONTROL PROJECTS

Table of Contents

Part I. Projects on Getting Organized* 3

- A. Know Your Local Mosquito District Manager and Services . . 5
- B. Know Your Local Environmental Teachers and Leaders 6
- C. Know Your State and Federal Mosquito Control Agencies . . 7
- D. Know Your Professional Mosquito Control Associations . . . 9

Part II. Projects on Control Operations and Skills* 12

- A. Know Your Control Area 14
  - 1. Making a Large Area Control Program Map 15
  - 2. Making Small Area Operations Maps 17
  - 3. Making an Attitude and Mosquito Bite Exposure Survey 22
- B. Know Your Mosquitoes* 26
  - 1. Making Collecting Equipment for Adult Mosquitoes . . 27
  - 2. Sorting Mosquitoes and Identifying Local Pest Species 34
  - 3. Making Adult Mosquito Surveys 47
- C. Know Your Mosquito Breeding Sites 51
  - 1. Making a Larval Mosquito Breeding Site Survey 52
  - 2. Classifying Breeding Sites by Priority for Control . 55
- D. Know Your Management Options 56
  - 1. Designing Public Education Leaflets (For the Management of Small Breeding Sites) 57
  - 2. Estimating the Amount and Sources of Funding 59
  - 3. Designing a Control or Management Program 60
  - 4. Estimating Costs for Large Area Control Options . . . 64
  - 5. Cost Sharing of Breeding Reduction with Landowner . . 65
  - 6. Forming an Organized Control District 66
  - 7. Calibrating Pesticide Application and Equipment* . . . 67

Part III. Projects on Improving the Reliability of Control Data* . 75

- A. Know Your Research Design for Reliable Data 77
  - 1a. Examining the Nature of the Random Force in T-F Tests 78
  - 1b. The Random Force and Experimental Design or How You Look at Things Determines What You See 79
  - 2. Summing Up the Variation in a Sample 80
  - 3. Interpreting Variation & Establishing Confidence Limits 81
  - 4. Significance Testing of Fixed Condition Effects . . . 84
- B. Know Your Mosquito Habitat Productivity Limits 91
  - 1. Mosquito Habitat Field Observations 92
  - 2. Mosquito Habitat Laboratory Observations 93
- C. Know Your Mosquito Behavior 95
  - 1. Mosquito Behavior Field Observations 96
  - 2. Mosquito Behavior Laboratory Observations 97

* Contains an expanded Table of Contents

Part I. Projects on Getting Organized

There are a number of people interested in mosquitoes and in helping others learn about them. These people work together. They can also use the help of keen observers who give thoughtful consideration to their observations. Depending upon where you live and the number of mosquitoes, you will be able to find from one to several people in the following projects. You can work alone, but your control or research projects will have greater value if you work with others and share your results.

A. Know your mosquito district manager.

If your community has an organized mosquito control district, there will be a manager interested in all the good help available. If you are a high school student or older, there may even be a part-time or summer job available plus training for the work. If there is no organized control district, there still may be a person working with the city or county who is responsible for keeping account of mosquitoes and taking steps to reduce their numbers.

B. Know your environmental teachers and leaders.

In all communities there are biology teachers who assign projects to individual students or to the entire class. You may need a project for a Science Fair. Outside the school are a variety of clubs and organizations interested in making the community a better place to live. They need worthwhile projects that can be done throughout the year. Depending upon your age, you may be a member of one ranging from 4-H and Scouts to senior citizen.

C. Know your State and Federal mosquito control agencies.

Your state and federal mosquito control agencies not only provide many services but also can use your help. They need to know the population size and the species of mosquitoes where you live. You may be able to operate a sampling station for them including a light trap. This information is used to predict disease outbreaks and to complete state species lists of mosquitoes. You can still be the first to collect a new species in your county.

D. Know your professional mosquito control associations.

The American Mosquito Control Association has published several helpful books and manuals. Its members and those of state mosquito associations are also good sources of information and help.

Part I. Projects on Getting Organized

Table of Contents

A. Know Your Local Mosquito District Manager and Services 5

B. Know Your Local Environmental Teachers and Leaders 6

C. Know Your State and Federal Mosquito Control Agencies 7

Figure 1. State Integrated Mosquito Management System 8

D. Know Your Professional Mosquito Control Associations 9

Table 1. State and Regional Mosquito Associations . 10

Table 2. Index Terms Used in the "Literature References to Mosquitoes and Mosquito-Borne Diseases", Mosquito News 11

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2. Olson, J. K., Texas A & M University. Application of the concept of integrated pest management (IPM) to mosquito control programs. Mosquito News 39(4):718-723.

3. Steelman, C. Dayton, Louisiana State University. Economic thresholds in mosquito IPM programs. Mosquito News 39(4):724-729.

4. Womeldorf, Don J., California Department of Health Services. Funding for integrated pest management in mosquito control. Mosquito News 39(4):729-731.

5. Johnson, Edwin L., Environmental Protection Agency. Pesticide regulation, pest management and mosquito control. Mosquito News 39(4):731-736.

Pest Control and Public Health. 1976. Volume V of Pest Control: An assessment of present and alternative technologies, the report of the Public Health Study Team, Study on Problems of Pest Control. Environmental Studies Board, National Research Council. National Academy of Sciences: Washington, D.C. 282 pages.

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* Specific references are listed that either will not be quickly dated or were the basis of writing a project. In general, the last two year's issues of Mosquito News will contain at least one article related to each of the projects. Check in Books in Print for other current references on mosquitoes.

Project I-A. Know Your Local Mosquito District Manager and Services

One or more of the following offices is interested in mosquitoes in your community. Contact each to find their part in mosquito control.

1. From the telephone book and necessary calls fill in the following:

   Mosquito district manager ______________________
   name

   ____
   phone number name and address of organized district

2. From phone calls, office visits, or letters fill in the following:

   a. City or County Health Department or District Sanitarian

      Entomologist or manager ______________________
      name

      ____
      phone number address

   b. County Extension Agent ______________________
      name

      ____
      phone number address

   c. Agricultural Stabilization and Conservation Service (ASCS)

      Person in charge of aerial photos ______________________
      name

      ____
      phone number address

3. Appointment dates: a. ______________________
   for visit to mosquito control office
   b. ______________________
   for field trip
   c. ______________________
   for manager to come to class or club meeting

4. From your notes prepare a report on one of the following:

   a. Services provided to the public by the office in charge of mosquito control.
   b. Field trip report on mosquito breeding sites and control.
   c. What people can do to reduce the number of pest mosquitoes.
   d. Newspaper report on one of the above appointments.

Projects completed:

		(Signed)
project or report title	date	manager, teacher, leader, parent

Project I-B. Know Your Local Environmental Teachers and Leaders

Every community has a number of people trained in basic biology and the environmental sciences. These people can help you with a project. Your project can also help the community. Find the following:

1. Biology, Science or FFA Teacher ____________________
   name

   office number ____________ laboratory room ____________

   phone number ____________ school ____________ address ____________

2. 4-H Leader ____________________
   name

   phone number ____________ club ____________ address ____________

3. Scout Leader ____________________
   name

   phone number ____________ troop ____________ address ____________

4. Community and Service Clubs interested in environmental improvement

   Club ____ Person Contacted ____ Phone Number

   a. ____________________
   b. ____________________
   c. ____________________
   d. ____________________

5. Projects and merit badges related to mosquito management

   Title ____ FFA, 4-H, Scouts, Class, Club

   a. Mapping ____________________
   b. Entomology ____________________
   c. Nature Study ____________________
   d. Orienteering ____________________
   e. ____________________
   f. ____________________

6. Prepare a report for class, club or news on the interest community teachers and leaders have in mosquito control.

Projects completed:

____________ ______ (Signed) ____________

____________ ______ ____________

project or report title ____ date ____ manager, teacher, leader, parent

Project I-C. Know Your State and Federal Mosquito Control Agencies

1. Your city, county, or school library will contain information useful in planning mosquito projects as well as addresses for state offices. Prepare a short statement (less than 100 words) on your interest in mosquito management. Include this statement in your letters for special information when writing the following agencies.

2. Request control information leaflets or booklets, the name of the person in charge of mosquito management, and inquire if a survey station is needed in your community to monitor pest species from:

   a. State Health Department ______________________
   Entomologist
   ____
   phone number address

   b. State Extension Service ______________________
   Entomologist
   ____
   phone number address

3. Request information on current research work in your community and the availability of a list and an identification key to the species of mosquitoes in your state from: (Also see Figure 1)

   Entomology Department ______________________
   Entomologist
   ____
   phone number your state university address

4. Request an index to topographic maps for your state and a copy of "What is a Topographic Map?" from:

   Branch of Distribution, US Geological Survey, P. O. Box 25286,
   Federal Center, Denver, CO 80225

5. If your county ASCS office does not have complete information on aerial photos, request "How Aerial Photos Can Help You" from:

   Aerial Photography Field Office, USDA, ASCS, P. O. Box 30010,
   2222 West 2300 South, Salt Lake City, UT 84125

6. Request a copy of "Mosquitoes of Public Health Importance and Their Control" from: (homestudy and other courses are also available)

   USHEW, PHS, Center for Disease Control, Atlanta, GA 30333

7. Request information on the safe and effective use of pesticides and on integrated pest management from:

   US Environmental Protection Agency, Washington, DC 20460

Projects completed:

______________	______	(Signed) ______________
______________	______	______________
project or report title	date	manager, teacher, leader, parent

STATE MOSQUITO MANAGEMENT SYSTEM

Within each state, a self-supported system exists composed of a central agency with personnel interested in mosquito control and the control district managers. These two groups are bound together by training sessions, periodic meetings, and annual reports. This is the functional core of a state system. It requires an annual training program for control and management personnel as a significant portion of these people are new each year.

The core interacts with two other subsystems. The central agency is supported by several state agencies which generally includes a University. This subsystem is typically the repository of technical expertise and the source of new control methods.

The third subsystem is composed of the mosquito control district (MCD) manager, supervisor or board, employees, the public, and the interactions between. The public is composed of mosquito breeders and mosquito feeders. Often the mosquitoes are being raised by the very person concerned about their presence.

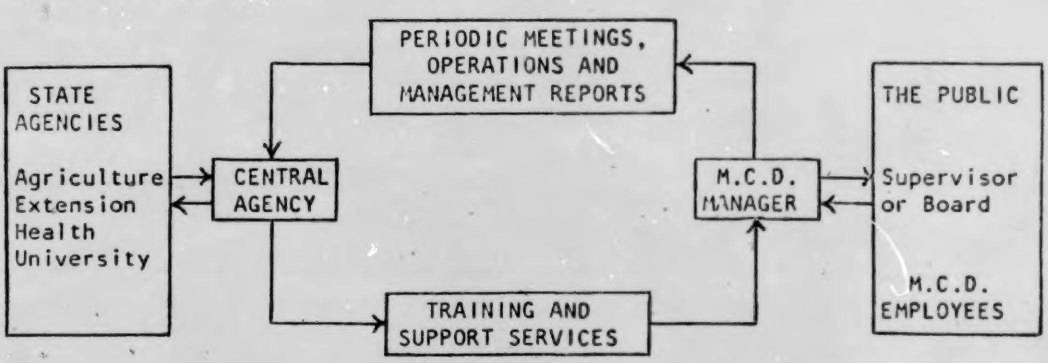

PERIODIC MEETINGS, OPERATIONS AND MANAGEMENT REPORTS
STATE AGENCIES
Agriculture
Extension
Health
University
CENTRAL AGENCY
M.C.D. MANAGER
THE PUBLIC
Supervisor or Board
M.C.D. EMPLOYEES
TRAINING AND SUPPORT SERVICES

Figure 1. State Integrated Mosquito Management System

In general, the three subsystems do not respond to the same goals or with the same timeliness. The uninformed mosquito ridden public is interested in nuisance control today. It is much less interested in measures that require long lead times characteristic of methods championed by integrated pest management principles. Application of these principles is more closely related to the interest of state agencies in predicting and preventing vectored disease outbreaks and abnormal pest populations. This places the MCD manager at the center of opposing forces unless long term IPM methods such as water management and source reduction can be demonstrated to the public to have a cost advantage in the long run. This requires local research (pilot) demonstrations and a convincing public education program.

Project I-D. Know Your Professional Mosquito Control Associations

Mosquito control work requires the cooperative efforts of a wide range of occupations and interested persons. Along with people interested in biology, ecology, public health, and engineering are those interested in teaching, public education, government and the new field of environmental mediation (how to solve one problem without creating several others). These people get together in state, regional and national associations in an effort to help one another in controlling mosquitoes (Table 1).

The national (and world wide) association is the American Mosquito Control Association, 5545 E. Shields Ave., Fresno, CA 93727, phone (209) 292-5329. It has recently published two booklets for schools and public education:

a. "Mosquitoes and Their Control in the United States", a 10 page color brochure, $1.00 per single copy.

b. "Mosquito Control Begins at Home", a 10 page cartoon coloring booklet for primary school to service clubs, 50¢ per single copy.

The series of Bulletins for the serious student and mosquito manager includes the following:

#1, 1980, The Use of Aircraft in the Control of Mosquitoes, $10.00

#4, 1961, Organization for Mosquito Control, $2.00

#5, 1970, Manual for Mosquito Rearing and Experimental Techniques, $3.50

1980, Key to the Mosquitoes of North America North of Mexico,
Supplement No. 1 to Mosquito Systematics, $

Membership is $20 (student $10). Members receive a newsletter and the quarterly journal of readable scientific and technical articles, Mosquito News. It is filled with ideas for projects including a reference section on articles published throughout the world (Table 2).

1. Locate your state or regional association ____________________
association name
____
person contacted phone address

2. Find the AMCA member in or nearest your community ____________
phone
____
name address

3. Prepare a report for class, club, or news on the services available from professional associations that will be of help in your project.

Projects completed:

____________________ ______ (Signed) ____________________

____________________ ______ ____________________
project or report title date manager, teacher, leader, parent

Table 1. State and Regional Mosquito Associations in EPA Region VIII

1.	Montana	Montana Mosquito & Vector Control Association Kenneth L. Quickenden Vector Control Specialist Dept. of Health & Environmental Sciences Helena, MT 59601 (406) 449-2408
2.	North Dakota	Mosquito Survey Committee Kenneth Tardif, Chief Division of Environmental Sanitation & Food Protection North Dakota State Department of Health 1200 Missouri Ave. Bismarck, ND 58505 (701) 224-2382
3.	Utah	Utah Mosquito Abatement Association Steven V. Romney, Secretary-Treasurer Manager, Uintah County MAD P. O. Box 983 Vernal, Utah 84078 (801) 789-4105
4.	Colorado South Dakota Wyoming	West Central Mosquito and Vector Control Association Ted Davis, Jr. Entomologist Colorado Department of Health 4210 East 11th Ave Denver, CO 80220 (303) 320-8333 Ben H. Kantack Extension Entomologist Cooperative Extension Service Entomology Department South Dakota State University Brookings, SD 57007 (605) 688-6176 Everett W. Spackman Extension Entomologist Cooperative Extension Service Plant Science Division University of Wyoming P. O. Box 3354 Laramie, WY 82071 (307) 766-4261

Table 2. Index Terms Used in the "Literature References to Mosquitoes and Mosquito-Borne Diseases", Mosquito News.*

Control Operations:	Fumigants
	Adulticides, larvicides and ovicides
	Growth regulators
	Integrated pest management
	Water management
	Mosquito control agency problems
	Parasites, predators, viruses and related agents
	Cost analysis
	Equipment
	Attractants and repellents
Applied Research:	Resistance and susceptibility
	Pesticides and chemicals
	Toxicology
Basic Research:	Behavior, biology, and ecology
	Genetics and genetic control
	Anatomy, morphology, and physiology
	Techniques--Tissue culture
	Taxonomy
	Distribution
Vectors of:	Several diseases
	Arboviruses and other vertebrate viruses--
	Encephalitis--California & St. Louis, Eastern & Western Equine, Japanese, Venezuelan Equine
	Dengue, Semlike Forest, Sindbis, West Nile
	Yellow Fever, Rift Valley Fever
	Filariasis--Dirofilaria
	Malaria--
	Cerebral
	Control and Eradication
	Immunology, Narcotics
	Parasites
	Simian
	Therapeutics and antimalarials--Resistance
	Transfusion
	Vectors
Mixed Research:	Experimental hosts or vectors
	Allergic reactions
	Light and other trap studies
References:	Literature references and reviews
	Biography and history
	Subjects not covered by other headings
	Booklets and reports
	Books
	Errata

* The Index Terms are listed in the sequence used to provide an insight into the interrelatedness of control and research activities as well as provide useful starting points in your library's card catalog.

Use *Books in Print* to discover books not in your library on mosquitoes.

Part II. Projects on Control Operations and Skills

The community that has an overworked summer mosquito control crew or a number of residents who are most unhappy with the number of mosquito bites being received is probably a community that did not do its homework before the "mosquito season". "Off season" management decisions can prevent the production of more mosquitoes at less expense than can attempts to kill them "in season". It is a big job.

The greatest success is when each person in the community knows what to do to prevent mosquitoes from breeding. Providing this information effectively is a very big job.

It has been divided into a number of projects that can be done in about any order. Some require a few hours and others several months. Many can be done outside the "mosquito season" when schools are open. Others can supplement current control efforts.

The projects are grouped into the four basic areas in which information must be developed before the best decisions can be made in selecting control options. The best options are those that produce the greatest benefit and environmental improvement at the least cost in money and in environmental damage. Each community must decide which habitat modifications are to be considered improvements and which are to be considered damaging to the environment. Without a careful study in all four areas, it is often impossible to tell.

A. Know your control area has projects on the making of maps and an attitude questionaire.

B. Know your mosquito projects include making collecting equipment, identifying pest species, and estimating their numbers. When attempts are made to kill biting females, one project will help determine the effectiveness of the application.

C. Know your mosquito breeding areas has larval sampling projects for the breeding season. Egg sampling for any time of the year is in project III-B.2.

D. Know your management options contains projects that reduce mosquitoes primarily by preventing their breeding. An informed organized community program is the secret to low cost mosquito reduction. This requires skill and patience in getting people to work together, the art of government.

Part II Projects on Control Operations and Skills

Table of Contents

A. Know Your Control Area 14

1. Making a Large Area Control Program Map 15

Figure 2. Portion of Eastlake Sectional 16

2. Making Small Area Operations Maps 17

Figure 3. Rectangular Survey System & Eastlake Area 18
Figure 4. Aerial Photographs Available from the ASCS 19
Figure 5. Ordering Aerial Photographs from the ASCS 20
Figure 6. Operations Map: Eastlake Res No. 2 . . 21

3. Making an Attitude and Mosquito Bite Exposure Survey . . 22

Figure 7. Mosquito Management Survey (Sample) . . 23
Table 3. Weighting Scales for Observations 24

B. Know Your Mosquitoes*. 25

1. Making Collecting Equipment for Adult Mosquitoes 26
2. Sorting Mosquitoes and Identifying Local Pest Species . . 33
3. Making Adult Mosquito Surveys 46

C. Know Your Mosquito Breeding Sites 50

1. Making a Larval Mosquito Breeding Site Survey 51

a. Building Two-Chambered Cages for Emerging Adults . . 52
b. Making a Pocket Larval Collecting Kit 53

2. Classifying Breeding Sites by Priority for Control . . . 54

D. Know Your Management Options 55

1. Designing Public Education Leaflets (For the Management of Small Breeding Sites) 56

Figure 9. Mosquito Control Leaflets, Examples . . 57

2. Estimating the Amount and Sources of Funding 58

3. Designing a Control or Management Program 59

Figure 10. AMCA Policy Statement on Mosquito Control 60
Figure 11. Community Mosquito Reduction Check List 61

a. News Bulletins and Group Project Status Reports . . 62

4. Estimating Costs for Large Area Control Options 63

5. Cost Sharing of Breeding Reduction with Landowner 64

6. Forming an Organized Control District 65

7. Calibrating Pesticide Application and Equipment*. 66

Figure 12. Spray droplet pattern 71

* Contains an expanded Table of Contents

II-A. Know Your Control Area

Learning to know your control area is the practical and scientific equivalent to the sport of Orienteering. Managing mosquitoes requires a thorough knowledge of the land and of the water in which they breed. The best way to assemble this information is in the form of maps.

Many helpful maps are available, however, the best ones are those you make yourself for your own needs. A base map is a map upon which you add special information. You can buy or make your own base maps. It is best to buy the base map that contains your entire control area.

It is best to make your own base maps for control operations. These are the maps on which you will plot mosquito breeding sites and other management information such as the prevailing wind direction during the mosquito season. In rough dry terrain, mosquitoes tend to migrate along paths with high relative humidity. This can produce horrendous populations at one spot and 50 feet away not a bite.

When out checking your operations maps, learn to recognize the types of vegetation associated with mosquito breeding and hiding places. Also keep an eye on what effect man's activities in construction and agriculture are having on producing or destroying mosquito breeding habitats. Keep on the watch for mosquito predators in the air and in the water. These observations will not only help in the control of mosquitoes but can often be used in the design of research projects.

Each breeding site is suitable for a limited set of good research studies. There are practical questions that must be answered to manage the site. The site may also be ideal for answering questions of a more general, scientific nature. Answers to these questions may be useful to the entire control area, for example, the location of Index or Reference sites for monitoring mosquito populations in the community.

The weather more than any other factor determines the wide range of mosquitoes in your community. In addition to the weather data from reference sources for your community also learn the general air flow patterns that carry mosquitoes into protected areas.

Project II-A.1 Making a Large Area Control Program Map

A program map helps to make people aware of the total problem. They need to be aware of the relative size and location of three areas:

The protected area: that area in which a minimum of mosquitoes is desired and where breeding must be prevented.

The barrier zone: that area around the protected area in which control operations must be carried out. It must be wide enough to prevent mosquitoes from easily flying across (1 block to 1 mile wide).

The outlying area: that area around the barrier zone in which no control operations are normally carried out.

1. Obtain a sectional topographic map for your area. The state index to topographic maps lists libraries that keep reference files of maps and dealers who sell maps in your state (Project I-C, #4). Order the largest scale (most detail) map for your area. This will usually be the 7.5 minute series with a sdale of 1:24,000 on which 1 inch represents 2000 feet. $1.25 each. It will provide an excellent overview of your area showing drainage patterns, railroads and main roads. The section numbers are also given that are helpful in ordering ASCS aerial photos of agricultural and urban areas(Fig. 2).
2. Obtain large scale road maps that show your area plus one to five miles around the barrier zone. Possible sources are the Highway Department, real estate and abstract offices, City Hall, Court House, Library, local newspaper office and regional planning offices.
3. To start your base map, select the map that shows the required area and has sufficient detail with which to identify property that may fall on either side of lines marking the barrier zone.
4. Use an opaque projector as an aid in transferring detail to your base map if the other map has a different scale.
5. Draw in what you think should be the protected area and the barrier zone. This is your proposed program map. Your protected area may be your house lot, block, farm, city, or a part of or a whole county.

Projects completed:

Obtained Topo Index _____ (Signed) ____________________

Obtained sectional _____ ____________________

Obtained road maps _____ ____________________

Completed base map _____ ____________________

Completed program map _____ ____________________

Prepared report on map _____ ____________________

date manager, teacher, leader, parent

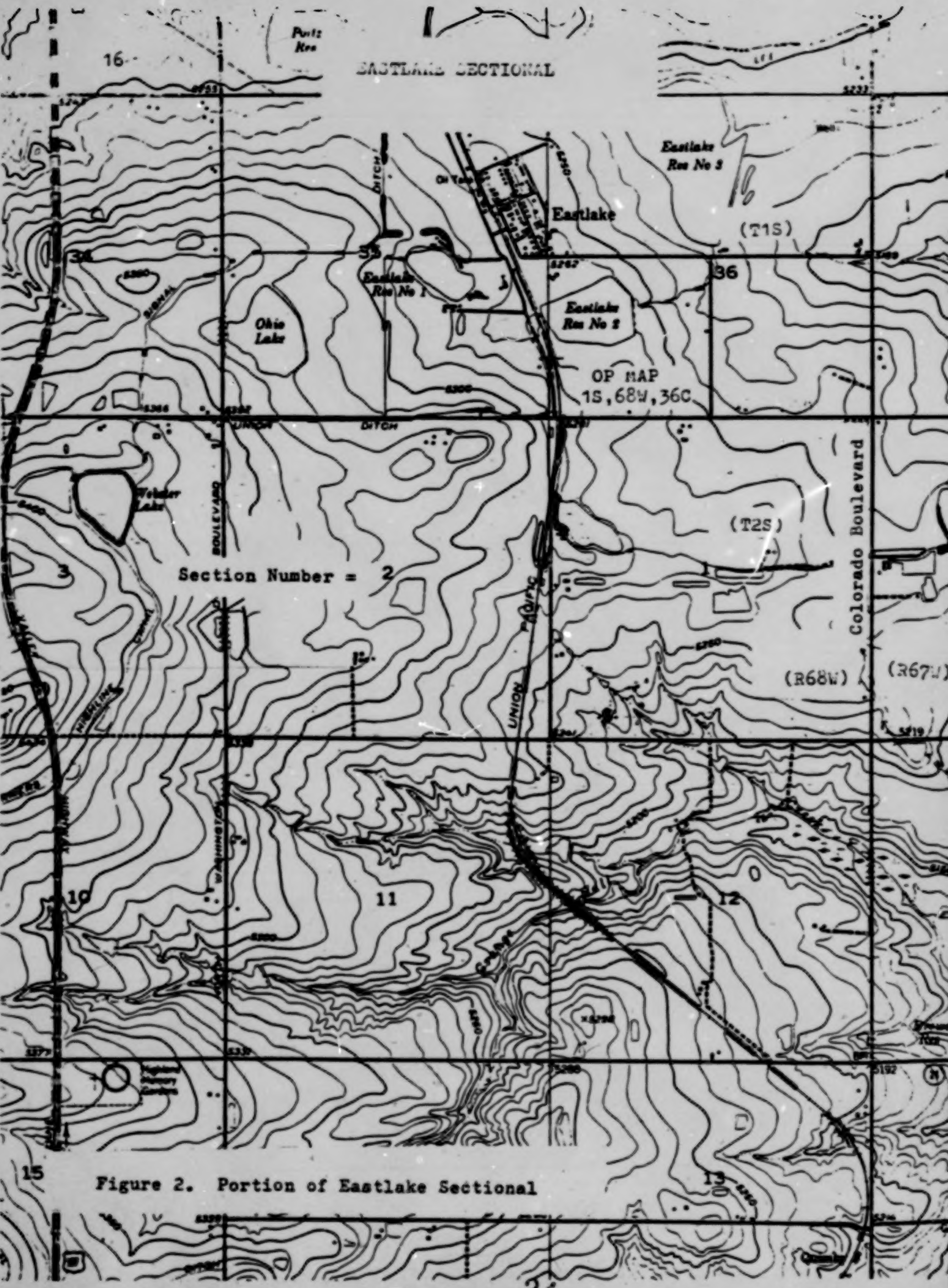

EASTLAKE SECTIONAL
Eastlake
Eastlake Res No 3
Eastlake Res No 1
Eastlake Res No 2
Ohio Lake
Webster Lake
Putz Res
DITCH
UNION DITCH
BOULEVARD
WASHINGTON
UNION PACIFIC
(T1S)
(T2S)
OP MAP
1S,68W,36C
Section Number = 2
Colorado Boulevard
(R68W)
(R67W)
16
34
35
36
1
3
10
11
12
13
15

Figure 2. Portion of Eastlake Sectional

Project II-A.2 Making Small Area Operations Maps

Operations maps must have a scale large enough to permit sketching in each mosquito breeding site. A convenient scale is 8 inches per ½ mile. This scale places a quarter section of land on an 8½ x 11 inch sheet with margins for notes and space for binding holes. Cities are often laid out with 10 and 16 blocks per mile or 40 blocks per sheet.

1. From the topographic map (sectional) of your area (Project II-A.1, #1) select the section numbers for aerial photos (Figure 3).
2. Visit your County ASCS office to order 10" by 10" contact prints of clear film base positive transparencies, $3.00 each (Figure 4). The photo index will show many overlapping photographs (Project I-C, #5). Each photograph will cover from 8 to 30 sections.
3. Double check your aerial photo order. It takes up to 30 days for an order to be printed. Any error delays your work a month and cost you more money. Use the photo index identification codes for the prints for faster service than that provided by the alternate means of ordering given on the order form (Figure 5).
4. Project your positive transparency onto a wall with an overhead projector. Find a pair of road intersections you know are a half mile or a mile apart. Move the projector toward or away from the wall until 8 inches equals ½ mile. Check this with more than one pair of roads. Your projector is now calibrated for the production of operations maps.
5. If you need to make more than one operations map, make up a code for identifying them in a systematic manner. One system is to use Township, Range, and Section numbers followed by A to D for the quarter sections (T3N,R8W,S12A) or (3N8W12A). Number your operations maps on the program map. Now you can make any operations map needed without having to enlarge the entire transparency. Also you can add operations maps in an orderly manner (Figure 6).
6. Prepare an operations map by projecting the desired area onto a sheet of paper and tracing in all roads and other landmarks that will aid in sketching (in the field) the location of mosquito breeding sites, the source of the water, and drainage routes. Include ponds, streams, and ditches. After visiting the site, again project the area. You will now notice detail you missed before. Make a few copies for plotting breeding sites (Project II-C.1).

Projects completed:

Ordered aerial photo ______ (Signed) ______________________

Projector calibrated ______ ______________________

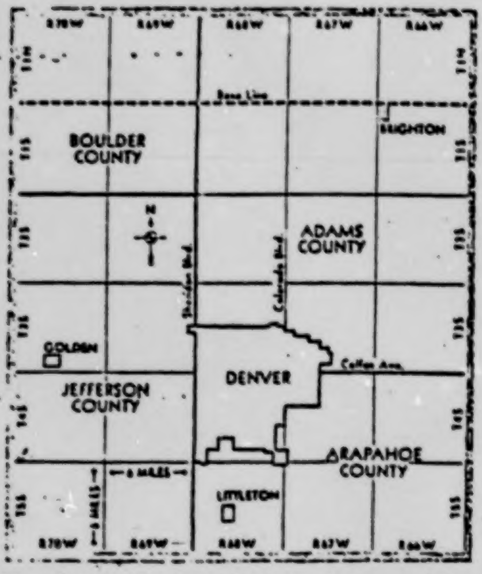
Map code selected ______ ______________________

Operations map completed ______ ______________________

Report prepared on map ______ ______________________

date manager, teacher, leader, parent

The Rectangular Survey System


R70W
R69W
R68W
R67W
R66W
Base Line
BOULDER COUNTY
BRIGHTON
N
Sheridan Blvd.
Colorado Blvd.
ADAMS COUNTY
GOLDEN
DENVER
Colfax Ave.
JEFFERSON COUNTY
ARAPAHOE COUNTY
6 MILES
6 MILES
LITTLETON

Map showing Denver and vicinity in terms of the actual Townships, Ranges and Sections.

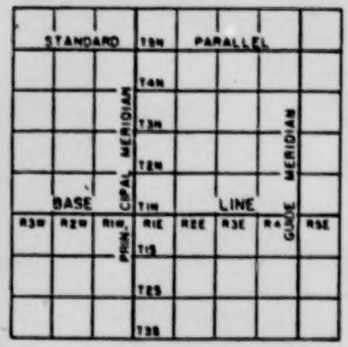
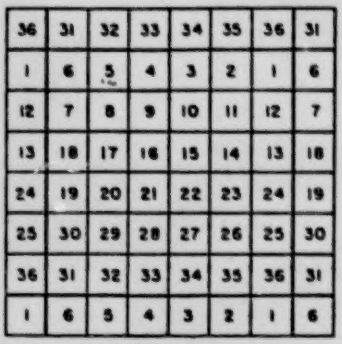

STANDARD
T5N
PARALLEL
T4N
T3N
T2N
T1N
BASE
LINE
PRINCIPAL MERIDIAN
GUIDE MERIDIAN
R3W
R2W
R1W
R1E
R2E
R3E
R4
R5E
T1S
T2S
T3S

Diagram showing division of tract into Townships



36	31	32	33	34	35	36	31
1	6	5	4	3	2	1	6
12	7	8	9	10	11	12	7
13	18	17	16	15	14	13	18
24	19	20	21	22	23	24	19
25	30	29	28	27	26	25	30
36	31	32	33	34	35	36	31
1	6	5	4	3	2	1	6

Sectional map of Township showing adjoining Sections

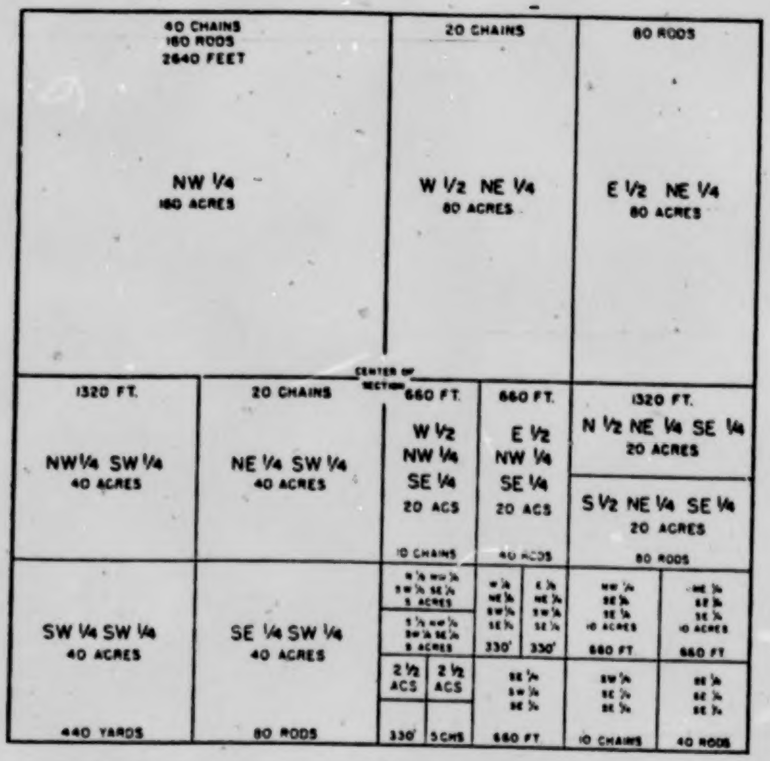

40 CHAINS
160 RODS
2640 FEET
20 CHAINS
80 RODS
NW 1/4
160 ACRES
W 1/2 NE 1/4
80 ACRES
E 1/2 NE 1/4
80 ACRES
CENTER OF SECTION
1320 FT.
20 CHAINS
660 FT.
660 FT.
1320 FT.
NW 1/4 SW 1/4
40 ACRES
NE 1/4 SW 1/4
40 ACRES
W 1/2 NW 1/4 SE 1/4
20 ACS
E 1/2 NW 1/4 SE 1/4
20 ACS
N 1/2 NE 1/4 SE 1/4
20 ACRES
S 1/2 NE 1/4 SE 1/4
20 ACRES
10 CHAINS
40 RODS
80 RODS
N 1/2 NW 1/4 SW 1/4 SE 1/4
5 ACRES
S 1/2 NW 1/4 SW 1/4 SE 1/4
5 ACRES
W 1/2 NE 1/4 SW 1/4 SE 1/4
E 1/2 NE 1/4 SW 1/4 SE 1/4
330'
330'
NW 1/4 SE 1/4 SE 1/4
10 ACRES
NE 1/4 SE 1/4 SE 1/4
10 ACRES
660 FT
660 FT
SW 1/4 SE 1/4
SW 1/4 SE 1/4
40 ACRES
SE 1/4 SW 1/4
40 ACRES
2 1/2 ACS
2 1/2 ACS
SE 1/4 SW 1/4 SE 1/4
SW 1/4 SE 1/4 SE 1/4
SE 1/4 SE 1/4 SE 1/4
440 YARDS
80 RODS
330'
5 CHS
660 FT
10 CHAINS
40 RODS

Figure 3. Rectangular Survey System and Eastlake Area

ASCS-441A
(3-6-78)

U.S. DEPARTMENT OF AGRICULTURE
Agricultural Stabilization and Conservation Service

19

PRICES FOR AERIAL PHOTOGRAPHIC REPRODUCTIONS

Prices Effective April 1, 1978

The prices listed below are effective until further notice. The prices given are for items most generally requested. Ordering instructions are shown on the back of the order form. Information regarding other available items will be furnished upon receipt of inquiry outlining needs.

TYPE AND APPROXIMATE SIZE OF REPRODUCTIONS	BLACK & WHITE		COLOR AVAILABLE ONLY FOR NATIONAL FOREST AREAS			
			FROM COLOR NEGATIVE		FROM COLOR POSITIVE	
	PAPER	1/ FILM BASE POSITIVE TRANSP.	PAPER	FILM BASE POSITIVE TRANSP.	WHITE OPAQUE BASE FILM	FILM BASE POSITIVE TRANSP.
2/ Photo Indexes 20" x 24"	$ 5.00	$15.00	▨	▨	▨	▨
3/ Contact Prints 4/ 10'' x 10''	2.00	3.00	$ 5.50	$12.00	$ 7.00	$12.00
Enlargements 12" x 12"	5.00	7.00	15.00	Prices	15.00	20.00
17'' x 17"	6.00	8.00	20.00		25.00	30.00
24" x 24"	7.00	10.00	25.00	Upon	30.00	35.00
38" x 38"	15.00	17.00	40.00	Request	45.00	50.00

1/ For screened transparencies, add $1.50 per print. When ordering this product, specify "Screened Transparency" on the order.

2/ Only Diazo line indexes of some Forest Service photography are available - $1.00.

3/ Contact prints are not available as sectionals, or with scale accuracy.

4/ Cronopaque black-and-white contact print 10" x 10" - $3.00. (Only available on 10" x 10" size.)

Aerial photography is obtained at various scales, only one or two of which are available of any given area. The majority of photography held by APFO is at the scales in heavy black type below.

SALE OF ORIGINAL PHOTO		DISTANCE ALONG ONE SIDE OF PHOTO	AVAILABLE IN	
FRACTIONAL SCALE	CONTACT PRINT SCALES FT./IN.		B&W	COLOR
1:15,840	1320 1/4 mi	2.25 miles	x	x
1:20,000	1667	2.84 miles	x	
7.5 min 1:24,000	2000	3.40 miles	x	x
1:31,680	2640 1/2	4.50 miles	x	
1:38,000	3167	5.40 miles	x	
1:40,000	3333	5.68 miles	x	
1:48,000	4000	6.81 miles	x	
1:58,000	4833	8.24 miles	x	
1:72,000	6000	10.22 miles	x	
1:80,000	6667	11.36 miles	x	
15 min 1:62,500	5208			
1:60,000	5,000			
1:120,000	10,000			

Enlargements from the aerial negative are available in the sizes and at the approximate scales shown in the following table. Scales requiring "sectional" enlargements are made for approximately ¼ of the negative. "Standard" sectional enlargements are available at no extra cost.

PAPER SIZE	DIAMETER OF ENLARGEMENT	APPROXIMATE FEET/INCH SCALE FROM		
		1:15,840 PHOTOGRAPHY	1:20,000 PHOTOGRAPHY	1:40,000 PHOTOGRAPHY
12" x 12"	1.26X	1" =1050'	1"=1320'	1"=2640'
12" x 12"	2.53X Sectional			1"=1320' Sectional
17" x 17"	1.66X	1"=790'	1"=1000'	1"=2000'
17" x 17"	3.33X Sectional			1"=1000' Sectional
24" x 24"	2.53X	1"=525'	1"=660' 1/8	1"=1320'
24" x 24"	5.05X Sectional		1"=330' 1/16 Sectional	1"=660' Sectional
38" x 38"	4.16X	1"=320'	1"=400'	1"=800'
38" x 38"	8.33X Sectional		1"=200' Sectional	1"=400' Sectional

Remittance is required before prints will be made. Make check or money order payable to ASCS. Official purchase orders are accepted for tax-supported agencies.

ADDRESS ORDERS FOR PHOTOGRAPHS TO:

Aerial Photography Field Office, ASCS-USDA
2222 West 2300 South, P.O. Box 30010, Salt Lake City, UT 84125
Telephone: (801) 524-5856 (Commercial) and 588-5856 (FTS)

Figure 4. Aerial Photographs Available from the ASCS

20

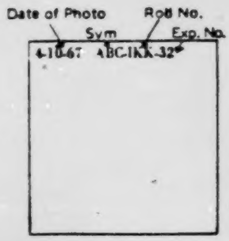
GENERAL

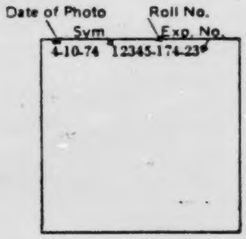
Three agencies of the USDA obtain aerial photography from their use. Agricultural Stabilization and Conservation Service (ASCS), Forest Service (FS), and Soil Conservation Service (SCS). The combined aerial photography covers about 90% of the nation, primarily the agricultural and national forest areas. About 95% of the photography was flown with black and white (B&W) panchromatic film. Natural color and color infrared (false color) has been flown only over national forest areas. Scale of the photography on file varies from 1:15,840 to 1:80,000 with about 15% at 1:15,840; 70% at 1:20,000; 10% at 1:40,000; and the remainder at various other scales. Recently, most photography has been flown at 1:40,000.

ORDERING AERIAL PHOTOGRAPHS

For assistance and/or information about ordering aerial photography, we suggest a visit to the county ASCS office, SCS field office, or the national forest office in your area.

Exposures available are identified in either of the following ways:





If the photo identification is not known, you may make the coverage selection necessary to meet your requirements in any of the following ways:

a. Furnish a map outlining your exact area of interest. We will then make the selection for you.

b. Send a detailed description of your area of interest for us to use in making selections. *(latitude-longitude, township-range, etc.)*

c. Visit the local county ASCS office, SCS office, or the local, Regional, or National Forest office.

d. Purchase the photo index sheets covering your area and then select the individual prints best suited for your needs.

IMPORTANT - On LABEL on face of order, print or type items 1 thru 4 only.

IDENTIFICATION OF PHOTOGRAPHY (Example Only)

SIZE AND TYPE OF REPRODUCTION	QUAN.	CODE OR SYMBOLS	ROLL NO.	EXPOSURE NO.
24" x 24" Enlargement	1	D J D	3A	96
24" x 24" Transparency	1	48041	173	89

Column 1. Enter size 9½" x 9½", 24" x 24", etc., 2nd Type of Reproduction. When ordering indexes enter "Photo Index" and list sheet numbers and year of photography.

Column 2. Enter number of prints wanted from each exposure number.

Columns 3, 4, and 5. Enter the code or symbol, roll number, and the exposure number of the negatives. Exposure numbers may be listed in inclusive sequences. This information is in the upper right corner of each photograph and may be obtained from photo-index sheets.

SCALES FRACTIONAL	SCALES FT./IN.	AREA COVERED BY ONE PHOTO	* TYPE OF PHOTOGRAPHY
1:15,840	1320	2.25 x 2.25 mi.	B&W/C/FC
1:20,000	1667	2.84 x 2.84 mi.	B&W
1:24,000	2000	3.40 x 3.40 mi.	B&W/C/FC
1:38,000	3167	5.40 x 5.40 mi.	B&W
1:40,000	3333	5.68 x 5.68 mi.	B&W
1:48,000	4000	6.81 x 6.81 mi.	B&W
1:58,000	4833	8.24 x 8.24 mi.	B&W
1:72,000	6000	10.22 x 10.22 mi.	B&W
1:80,000	6667	11.36 x 11.36 mi.	B&W

*B&W = Black & White Panchromatic Film
C = Natural Color
FC = False Color Infrared

PRINT SIZES & TYPES OF REPRODUCTIONS

Contact Prints are the same size as aerial negatives, approximately 9x9 inches. ASCS aerial photography is flown at two different negative scales

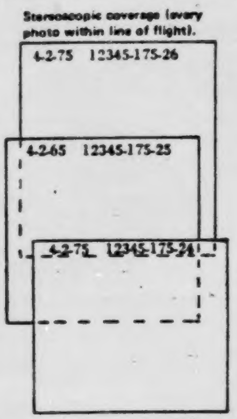
1:20,000 (1"=1667'), the area covered by a contact print is about 8 square miles.

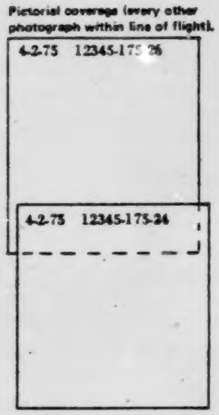
1:40,000 (1"=3334'), the area covered by a contact print is about 32 square miles.

Prints are available with either stereoscopic or pictorial overlap.

Stereoscopic Coverage requires each consecutively numbered print in the line of flight which gives an endlap of about 65% between adjacent prints.

Pictorial Coverage requires alternate numbered prints in the line of flight resulting in an endlap between prints of about 30%.




Pictorial coverage (every other photograph within line of flight).
4-2-75 12345-175-26
4-2-75 12345-175-24

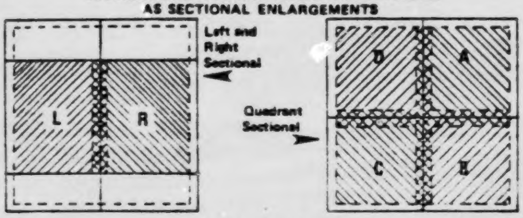
Contact prints are not available as sectionals or with scale accuracy.

Enlargements from the aerial negative are available in the sizes and at the approximate scales shown in the following table:

SIZE	DIAMETER OF ENLARGE.	APPROX. SCALE FROM 1:15,840 PHOTOGRAPHY	APPROX. SCALE FROM 1:20,000 PHOTOGRAPHY	APPROX. SCALE FROM 1:40,000 PHOTOGRAPHY
12" x 12"	1.26X	1"=1050'	1"=1320'	1"=2640'
12" x 12"	2.53X Sectional			1"=1320' Sectional
17" x 17"	1.66X	1"=790'	1"=1000'	1"=2000'
17" x 17"	3.33X Sectional			1"=1000' Sectional
24" x 24"	2.53X	1"=525'	1"=660'	1"=1320'
24" x 24"	5.05X Sectional		1"=330' Sectional	1"=660' Sectional
38" x 38"	4.16X	1"=320'	1"=400'	1"=800'
	8.33X Sectional		1"=200' Sectional	1"=400' Sectional

Scales requiring "sectional" enlargements are made for approximately ¼ of the negative. Standard sectional enlargements are available at no extra cost for the following portion of the negative.

APPROXIMATE AREAS OF NEGATIVE AVAILABLE AS SECTIONAL ENLARGEMENTS



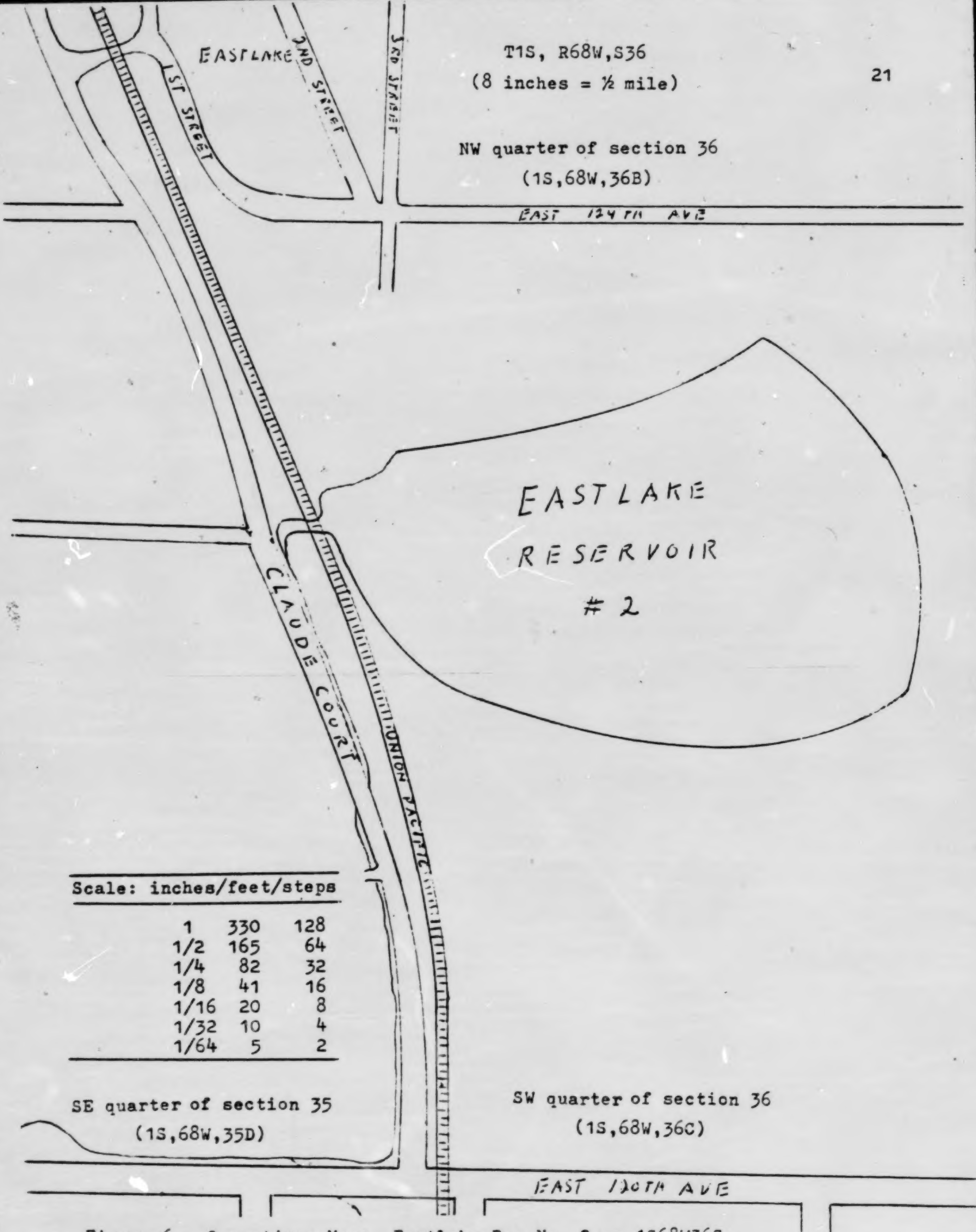
The enlarged areas are indicated with crosshatch marks. There is some loss of image on the outer edge of the print due to overlap between SECTIONALS.

Photo Indexes are available for ASCS, SCS, and some FS aerial photography. They show the assembly of prints covering each project area, generally a county or portion thereof. They are copies at a reduced scale, usually about 1" to the mile on 20 x 24 inch paper. If you are selecting a large quantity of prints or have a continuing need for this type of information, you may want to purchase the photo indexes which cover your area of interest. **Other reproductions** are available, transparencies, duplicate negatives, etc. **Remittance** is required before prints will be made. Make check or money order, payable to ASCS. Official purchase orders are accepted for tax supported agencies.

Address Orders for Photographs to:
Aerial Photography Field Office, ASCS-USDA
2222 West, 2300 South, P.O. Box 30010, Salt Lake City, UT 84125
Telephone: (801) 524-5856 (Commercial) and 588-5856 (FTS)

Figure 5. Ordering Aerial Photographs from the ASCS

T1S, R68W,S36
(8 inches = ½ mile)


EASTLAKE
1ST STREET
2ND STREET
3RD STREET
NW quarter of section 36
(1S,68W,36B)
EAST 124TH AVE
EASTLAKE RESERVOIR # 2
CLAUDE COURT
UNION PACIFIC
SE quarter of section 35
(1S,68W,35D)
SW quarter of section 36
(1S,68W,36C)
EAST 120TH AVE

Scale: inches/feet/steps		
1	330	128
1/2	165	64
1/4	82	32
1/8	41	16
1/16	20	8
1/32	10	4
1/64	5	2

Figure 6. Operations Map: Eastlake Res No. 2 or 1S68W36C

Project II-A.3 Making an Attitude and Mosquito Bite Exposure Survey

A control area contains a variety of people with a wide range of experience with mosquitoes. Some people are not aware of their existence. Others call every small insect a mosquito. The exposure to mosquitoes and the human response must be determined. Two limiting factors are the acceptance of present conditions and the cost of changing those conditions.

1. Select homes and businesses in each of the three regions of the proposed or present control area:
   - a. Protected area - minimum mosquito populations
   - b. Barrier zone - minimum to normal populations across ¼ to 1 mile
   - c. Outlying area - normal mosquito populations
2. Prepare a questionaire including at least one question from each of the following four groups. Suggested statements are given including a sample questionaire (Figure 7) and a weighting scale (Table 3) for tabulating results. These statements can be used, but there may be others that are more appropriate for your community.
   - a. Exposure at home or business: Number of persons exposed
     Hours each person exposed
     Activities interfered with
     Severity of exposure
     Landing or biting rates
   - b. Human response: Physiological response
     Activity limitation response
   - c. Acceptance of present conditions:

     Degree of acceptance
     Method of acceptance: repellents, clothing, screening, avoidance, limit time in area
   - d. Cost of change:

     Price willing to pay for acceptable control per year
     Method of payment: tax, assessment, part of business operation
3. Administer the questionaire (personal interviews are best).
4. Conclusions for the control area:
   - a. The community is, is not, in need of mosquito control.
   - b. Protected area and barrier zone boundaries, are, are not, fair.
   - c. More sampling is, is not, needed to confirm boundaries.

Projects completed:

Questionaire designed ______ (Signed) ______________________

Questionaire administered ______ ______________________

Data tabulated & discussed ______ ______________________

______________________ ______ ______________________

report title date manager, teacher, leader, parent

Mosquito Management Survey (Sample)
Human Attitudes and Exposure to Biting Mosquitoes

Date __________ Sampler ________________________ Sample Number _____

Check the location of household or business:

___ Protected Area ___ Barrier Zone ___ Outlying Area

Record the age and check the frequency of bites for each occupant:

A. Frequency of bites per 24 hour period during mosquito season	Occupants and their ages							
	1	2	3	4	5	6	7	8
Ages:								
None								
Less than half the time								
About half the time								
More than half the time								
Every 24 hour period								

B. Response to bites

None								
Mild								
Severe								

C. Acceptance of present conditions

No change in activity								
Avoids mosquitoes part of the time								
Avoids mosquitoes all of the time .								

D. If control measures are desired, circle the price willing to pay per year for acceptable mosquito control by:

Household, or	$ 5	10	15	20	25	50	75	100	125
Wet acre, or	$.10	.30	.50	.70	1	2	3	4	5
All acres, or	$.01	.03	.05	.07	.10	.20	.30	.40	.50
Mill levy (mill)	0.1	0.3	0.5	0.7	1	2	3	4	5

For the preferred methods of payment, circle the rankings:

Special district property tax	1	2	3
General property tax	1	2	3
Wet acre	1	2	3
Household or business assessment	1	2	3
Volunteer work	1	2	3
Part of farm or business operation	1	2	3

Use back for descriptive comments on livestock, property values, encephalitis, activities interrupted by mosquitoes and other information.

Figure 7. Sample Questionaire for Management Information

Table 3. Weighting Scales for Observations and Subjective Responses

Number of Options	Subjective Assessment	Weights	
2	No or none	0	F
	Yes or some	1	T
3	None, never	0	
	Some, part of the time	1	
	All, all the time	2	
5	None	0	F
	Less than half the time	1	D
	About half the time	2	C
	More than half the time	3	B
	All the time	4	A
7	None	0	
	Almost none	1	
	Less than half	2	
	About half	3	
	More than half	4	
	Almost all	5	
	All	6	
9	None	0	
	Almost none	1	
	Much less than half	2	
	Less than half	3	
	About half	4	F
	More than half	5	D
	Much more than half	6	C
	Almost all	7	B
	All	8	A

II-B. Know Your Mosquitoes

To manage mosquitoes you must know the pest species. This unlocks information in the reference literature for you. Here you will find recorded the behavior of the 3 to rarely more than 7 species that carry disease or make a nuisance of themselves in your community. Of importance is their biting behavior and their selection of hosts, egg laying sites, and shelter for daytime and overwinter.

To know the pest species you must first collect them. A few can be collected by placing a small killing vial over them. A lot more can be obtained by a battery powered collector you can build. As a light trap it will collect males if near their breeding site. Adults can also be obtained by collecting the wigglers and tumblers (larvae and pupae) and holding them in a cage until they become adults.

Learning to know your mosquitoes involves a series of steps:

1. Making collecting equipment for adult mosquitoes contains directions for making collecting equipment for a few or for hundreds of specimens.

2. Sorting mosquitoes and identifying local pest species gives directions for identifying mosquitoes by their relative abundance. This method simplifies identification of pest species as you learn to recognize at sight the 3 to 7 species that make up over 90% of any collection.

3. Making adult mosquito surveys contains a variety of sampling methods used to learn the abundance of mosquitoes in a community. Some require no equipment other than paper, pencil, and a watch.

   After the first species and population surveys are completed, check through the research designs in Part III before selecting reference or index stations. Proper sampling not only saves time and money but produces valid comparisons of pest populations with respect to time, place, and control measures.

References:

Nielsen, Lewis T. September 1979. Mosquitoes, the mighty killers. National Geographic 156(3):426-440.

Center for Disease Control, Vector Topics:

No. 1, Control of St. Louis Encephalitis, 35 pages.

No. 2, Control of Dengue, 39 pages.

No. 3, Control of Western Equine Encephalitis, 35 pages.

No. 4, Biology and Control of Aedes aegypti, 68 pages.

II-B. Know Your Mosquitoes

Table of Contents

1. Making Collecting Equipment for Adult Mosquitoes 27

    Table 4. Suppliers of Mosquito Collecting Equipment . . 28
    Table 5. Suppliers of Collecting and Mapping Equipment 28

    a. Making a Chloroform Collecting Vial 29
    b. Completing the Motor Mount and Fan Chamber 30

    Figure 8. Battery powered Collector and Light Trap . . 31

    c. Completing the Collecting Capsule 32
    d. Making Collections with the Battery Powered Collector . . 33

2. Sorting Mosquitoes and Identifying Local Pest Species 34

    Table 6. State Lists and Classical Mosquito Drawings . 35
    Table 7. Potential Pest Species in Region VIII 36
    Table 8. Ranking of Mosquitoes in Region VIII by Comparative Abundance 37
    Table 9. Twenty-Seven Pest Species in Region VIII . . . 38
    Table 10. Breeding Sources Commonly Inhabited by Pest Species 39

    a. Recognizing the Two Most Abundant Species 40

    Table 11. Characters to Use in Sorting Pest Mosquitoes into Groups 41

    b. Recognizing the Second Two Most Abundant Species 42
    c. Selecting Sight Recognition Characters for Rapid Sorting 43
    d. Recognizing the Second Four Most Abundant Species 44
    e. Recognizing the Second Eight Most Abundant Species . . . 45
    f. Labeling and Preserving Pest Specimens 46

3. Making Adult Mosquito Surveys 47

    a. Making Species and Population Surveys 48
    b. Making an Adulticiding Quality Control Survey 49

    Table 12. Layout, Terms and Calculations for Area Quality Control Surveys 50

Project II-B.1 Making Collecting Equipment for Adult Mosquitoes

Standardized equipment is sold for collecting adult mosquitoes (Tables 4 & 5). The results are comparable around the world. Suitable equipment can be made for most collecting purposes at a savings. A wide variety of devices have been used which means that none do a top notch job for all species. The following projects on making your own equipment are for those species that land on or bite humans or other hosts from which you then collect the mosquitoes.

The battery powered unit collects landing mosquitoes before they can inflict painful bites and keeps the specimens in good condition. The parts cost between $3 and $5. With the exception of the "grain-of-wheat" bulb; a 200 milliamp, 3 volt motor (both from BioQuip Products); and a 3 inch propeller, all parts are from common household items. Directions are given for the lowest cost model (Figure 8) that performed satisfactorily during the summer of 1979.

The battery powered unit will also attract males if used near their breeding site. Males do not fly very far. If you collect several males, you know there is a breeding site within a few 100 feet.

The two types of collectors are easy to build and to use in both practical control work and in experiments. A set of three chloroform vials fits in a pocket and works well with low level pest populations. The battery powered unit will harvest a hundred in a few minutes from high level pest populations.

The two collectors are each but one example of their type. Step by step instructions are given for each. Many different modifications can be made.

a. Read the instructions through and make a list of parts and tools you have and of those you need.

b. Obtain the needed parts and tools.

c. Assemble the selected unit.

References:

Pratt, H. D., R. F. Darsie, Jr. and K. S. Littig. 1976. Mosquitoes of Public Health Importance and Their Control. USDHEW, PHS, CDC, Atlanta, 68 pp.

Service, M. W. 1976. Mosquito Ecology: Field Sampling Methods. Applied Science, London, 583 pp. ($76, AMCA)

SEE ADDENDUM for new inexpensive fan unit.

Table 4 Suppliers of Mosquito Collecting Equipment*

American Biological Supply Company, 1330 Dillon Heights Ave., Baltimore, Maryland 21228. (301) 747-1797. Catalog for the professional, amateur, or just plain collector. (No minimum order)

BioQuip Products, P. O. Box 61, Santa Monica, CA 90406. (213) 322-6636. Equipment, Supplies & Books for Entomology & Botany Catalog. ($15 minimum order)

Concession Supply Company, 1016 N. Summit Street, P. O. Box 1007, Toledo, OH 43697. (419) 241-7711. Mosquito traps brochure.

Hausherr's Machine Works, Old Freehold Road, Toms River, NJ 08753. (201) 349-1319. Light traps and aspirator brochure.

John W. Hock Co., P. O. Box 12852, Gainesville, FL 32604. Light trap brochure.

Table 5 Suppliers of Weather, Mapping and Collecting Equipment

Ben Meadows Company, 3589 Broad Street, Atlanta, Georgia 30366. (404) 455-0907. Forestry, Engineering and Educational Supplies Catalog. ($1 service charge on orders less than $5)

Carolina Biological Supply Company, Burlington, NC 27215. (919) 584-0381. OR Gladstone, OR 97027. (505) 656-1641. Biological Materials Catalog. ($15 minimum order)

Edmund Scientific Co., 101 E. Gloucester Pike, Barrington, NJ 08007. (609) 547-3488. Hobbyist, school, and industry scientific catalog. (No minimum order)

Turtox/Cambosco, 8200 S. Hoyne Ave., Chicago, IL 60620. (312) 488-4100 or toll free (800) 621-8980. Life, Earth & Physical Sciences Catalog. ($25 minimum order)

Ward's Natural Science Establishment, Inc., P. O. Box 1712, Rochester, NY 14603. (716) 467-8400. OR P. O. Box 1749, Monterey, CA 93940. (408) 375-7294. Entomology Catalog. ($15 minimum order)

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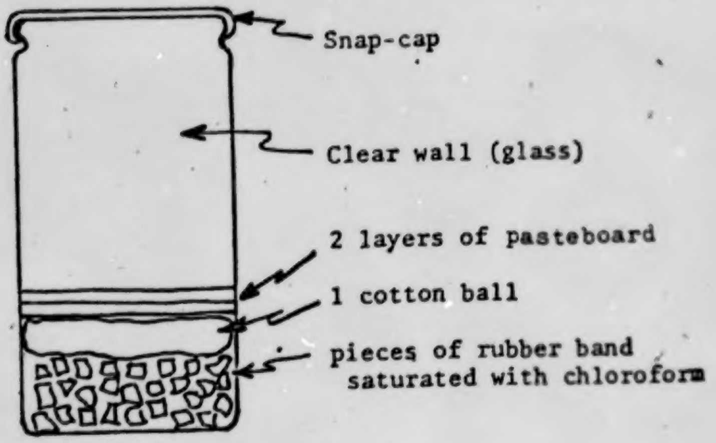
* For suppliers of pesticide application equipment and materials see advertisements in Mosquito News or trade journals.

Project II-B.1a Making a Chloroform Collecting Vial



1. Select a snap-cap vial or bottle with clear sides. The Wheaton #30, 1½ oz, glass bottle fits in a pocket and is resistant to breakage.
2. Drop in enough pieces of rubber band to just cover bottom of vial.
3. Pour in ½ inch of chloroform. (Chloroform is a toxic anesthetic. Use only with adult supervision.)
4. Let vial stand 2 to 4 hours for the chloroform to be absorbed.
5. When no liquid is left, or any present is poured out, shake the saturated rubber down and add one cotton ball.
6. Cut 2 disks of pasteboard a bit larger than the inside of the vial, add on top of the cotton ball, and press down firmly.
7. The pasteboard and vial wall should be dry. If not, leave the cap off a few minutes to evaporate the excess chloroform.
8. Put snap-cap on and vial is ready for collecting mosquitoes.
9. With skill, several mosquitoes can be collected from the lower side of an arm or leg without waiting for each one to be knocked out.
10. About 20 mosquitoes can be collected before they should be emptied into a holding container.
11. The charged vial should be usable for about 3 weeks.
12. To recharge, remove pasteboard and cotton, and add chloroform.

Projects completed:
1. One vial ______ (Signed) ____________________
2. Set of three ______ ____________________
date manager, teacher, leader, parent

Project II-3.1b Completing the Motor Mount and Fan Chamber

Motor mount. Mark and cut a 6½ oz (tuna, pet food, or short pineapple) can bottom as sketched in Figure 8 -A. Bend Tabs A and B up and press around the 200 milliamp, 3 volt motor. Tape the motor to Tab A. Then encircle Tabs A and B with tape while holding the motor in central alignment. Fold up Tabs E and D and then fold the sharp points over to lock the motor in place. Fold Tabs E and F similarly. The leads from the motor (multi-stranded speaker hookup wire) should run through the base of the folded triangular tabs. Fasten the 3 inch propeller to the motor shaft. Check the motor rotation by holding the motor leads to a D cell. Mark the polarity for the rotation that draws air down past the mounted motor.

Fan chamber. Cut the bottom from a 6½ oz nut can (with plastic outer lid and snap-out inner lid). Check the motor alignment by lowering the nut can over the mounted motor and turning the propeller by hand. These 2 cans MUST have the same diameter. Twist the motor mount if a small adjustment is needed. Again connect the motor leads to the D battery to check alignment and proper motor rotation. Secure the fan chamber to the motor mount with duct tape.

Battery pack and wiring. Tape 2 D cells together, side by side, with one battery inverted. Connect the batteries in series at one end of the pack with a narrow strip of aluminum foil covered with a piece of electrician's tape. Fasten the battery pack to the fan chamber with duct tape (Fig. 8 -C). Position the 3 volt "grain-of-wheat" bulb in the center of the fan chamber even with the snap-out inner lid. Hold the bulb in place with tape on the outside of the can. Twist together one lead from the bulb and one from the motor and fasten to the exposed positive pole of the battery pack with electrician's tape. Twist the remaining leads from the bulb and motor and fasten to a switch made of folded over electrician's tape (Fig. 8 -D). For OFF fasten to the side of the battery pack. This keeps the tape clean and sticky. For ON stick the switch to the exposed negative pole of the battery pack.

The above unit when suspended vertically with the bulb raised about ½ inch above the rim and fitted with a thin mesh sock at the lower end makes a "CDC" type light trap. Over half the specimens are damaged by the propeller.

Projects completed:

1. Wired motor mount and fan chamber completed ______ (Signed) ________________________
2. Unit rigged as a CDC light trap ______ ________________________

date manager, teacher, leader, parent

SEE ADDENDUM for new inexpensive fan unit.

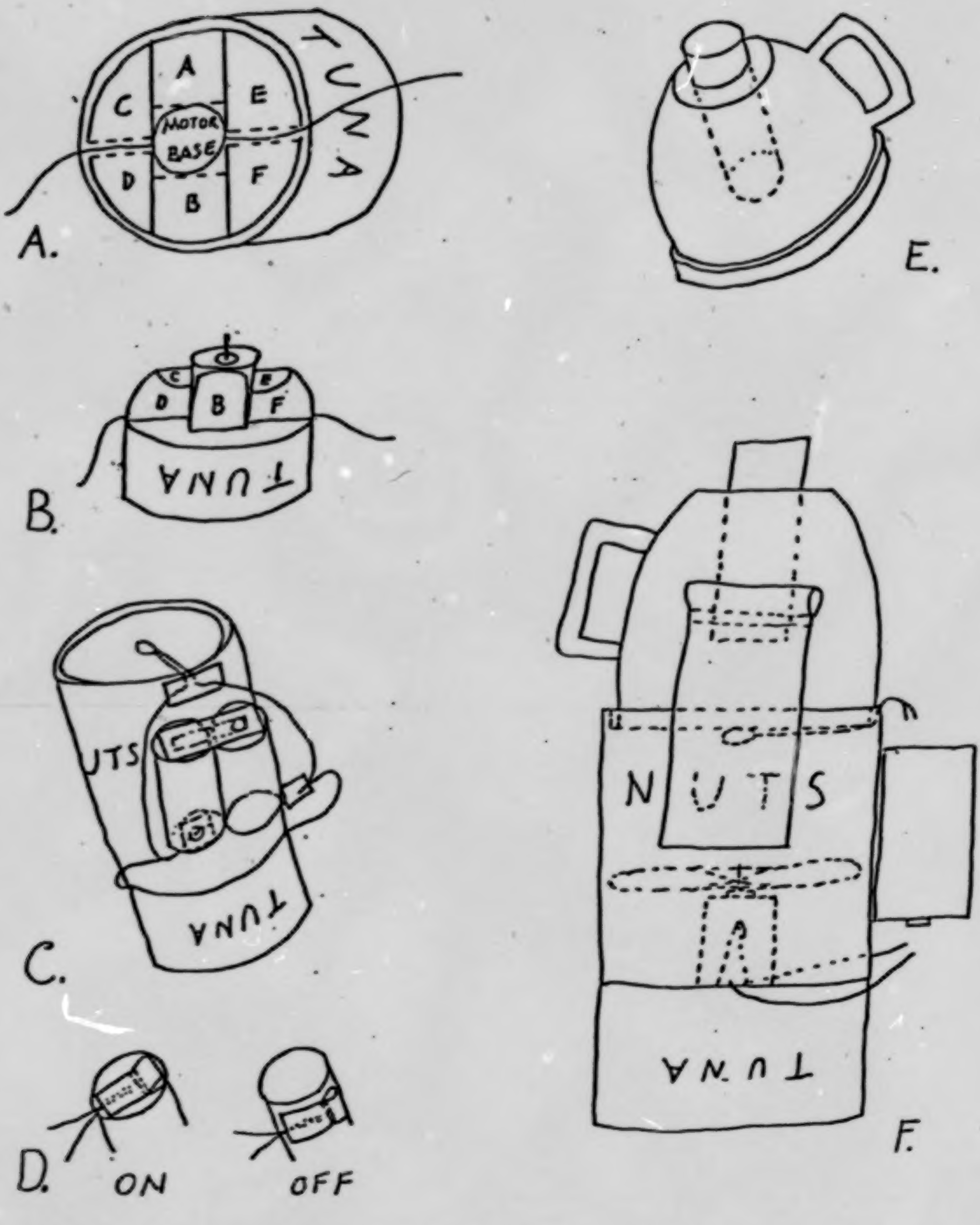

A
C
MOTOR BASE
E
D
F
B
TUNA
A.
E.
C
E
D
B
F
TUNA
B.
UTS
TUNA
C.
NUTS
TUNA
F.
D.
ON
OFF

Figure 8. A battery powered mosquito collector and light trap presented in individual parts (A through E) and assembled. A. motor mount marked for cutting and folding of tabs; B. motor mount completed; C. fan chamber with battery pack and wiring; D. tape switch; E. collecting capsule; F. assembled unit.

Project II-B.1c Completing the Collecting Capsule

Cut a hole in the bottom of an 11 oz all-purpose plastic mug (Woolsworth) in which to fit the collecting tube and plug (Mr. Misty Freeze, Dairy Queen; Yogurt Pops, Safeway; or a toilet tissue roll) (Fig. 8 -E). A rubber band around the collecting tube makes a good seal if the cut is not entirely true. Cover the top of the cup with a fine open mesh (thin hose) held in place with a rubber band. Trim the mesh close to the band. Secure the rubber band and mesh with duct tape. Another 2 or 4 layers of ½ inch wide duct tape may be needed to build the rim out to make a good seal when set into the top (resting on the lip of the snap-out lid) of the fan chamber. Hold the collecting capsule in place on the fan chamber with two duct tape tabs made with folded over ends. To remove the capsule, peel one tab down to the fan chamber and then grasp the capsule and slowly pull the two units apart. With care the tape tabs will last all summer.

A variety of collecting capsules can be built and tested. Anything that can be matched to the fan chamber will work with two limitations:

a. the mesh must be of light weight and
b. the collecting tube must not be smaller than the above tubes or airflow will be inadequate.

The collecting tube has two functions:

a. it permits the specimens to roost on the inside of the cup without being knocked about by air turbulence
b. its small diameter makes it easier to collect mosquitoes from irregular surfaces.

The clear plastic tube makes the best use of the light. It can be used as is (Mr. Misty Freeze) or with about 1/3 cut off.

Collections at different times or places can be kept separate by making several collecting capsules. Live mosquitoes (30 to 50) can be kept in good condition for several days by placing a wet cotton ball (touched to sugar) on the mesh. Aedes will even lay eggs on the wet cotton. Several hundred mosquitoes can be collected in a capsule without loss of adequate airflow. The mosquitoes are easily killed by placing the capsule on its side in the freezer or in a plactic bag with a killing agent.

Projects completed:

1. Capsule completed ______ (Signed) ______________________________

2. Capsule of your design completed ______ ______________________________
date   manager, teacher, leader, parent

Project II-B.1d Making Collections with the Battery Powered Collector

Hand held. Remove the plug in the collecting tube after turning on the motor. The light will shine down the collecting tube to aid in both finding mosquitoes and luring them into the collector. Rapidly approaching the mosquito from the rear with the collecting tube touching the surface just before hitting the mosquito insures a quick capture. They can also be collected on the wing. The batteries will run the unit about 12 hours of intermittent running time.

Attended light trap. Suspend the unit horizontally on a cord so the light shines downwind (the wind will help hold it in position). The batteries will last about 8 hours of continuous operation. No differences were found between clear and opaque collecting tubes in the numbers of males or females collected. The effects of different colors of cups or lights were not tested.

Unattended light trap. A commercial battery rack should be used and all connections soldered to improve durability and ease of operation. A 300 milliamp battery eliminator can also replace the batteries (#48 G 20795, Montgomery Ward). Oiling the motor bearings has been suggested for such heavy use. To make this possible, a hole must first be made in the center of the motor base before cutting out the Tabs.

Non-directional light trap. A non-directional configuration is made by mounting the bulb below the outer end of the collecting tube. A rubber band will hold it in place. The unit is suspended vertically with the bulb at the bottom. Mosquitoes are drawn in but the airflow is not strong enough to lift heavy bodied insects up into the capsule.

Light versus bait. A rule of thumb is that a plain light trap will collect about 1/10 the number of mosquitoes as a baited light trap. If you sit down near the light trap and collect the mosquitoes landing on your arms and legs as fast as they arrive with a hand held unit, all the males will be in the fixed trap and the females will be in the hand held unit. As you move farther from the fixed trap, it will collect more females.

Mosquito approach path. Close observation will show different species will arrive by different routes. Most seem to stay near the ground and then come up to the trap or the bait (person).

Projects completed:

		(Signed)
project or report title	date	manager, teacher, leader, parent

Project II-B.2 Sorting Mosquitoes and Identifying Local Pest Species

Adult female mosquitoes, the ones that bite, can be identified in several ways:

a. by comparing with identified specimens
b. by using a taxonomic key to the species of the state (Table 6)
c. by having someone who knows the species identify them
d. by sorting a number of specimens from a light trap or landing-biting collection into like groups, counting the number in each group and then comparing with a descriptive frequency table.

The last method is the simplest and the most available for the beginner. A 10X hand lens or magnifier and a good light such as the high intensity lamps sold in department stores for $12 to $20 are suggested.

The sort and count method is similar to the system taxonomists used in the original classification and naming of mosquitoes. If a group was sorted out for which no name had been created, the new group was carefully examined for a feature that set it apart from the rest of the collection. This feature was added to the identification key and a new name was given to the specimens in this new group.

The sort and count method repeats this process with one difference. Instead of having to make up a new name for each group, one can find what name has already been assigned to the specimens in each group. A scientific name can be used for only one species throughout the world. Regardless of the language spoken in a country, each species name of two Latin words (often underlined) is the same everywhere.

In the six states in Region VIII, the most common pest species (Tables 7-10) are all marked with white bands, strips or rings on one or more body part (Table 11). By looking at these strips, the general color and size of the body, and the structures at both ends of the body, the pest species can be sorted into 1 to 9 groups from any one collection. Often most of the specimens will all sort into but 3 or 4 groups. There usually will be a few specimens that do not look like any of the others. These are not in sufficient number to be pests, but keep them for later identification when time and skill permit determining the correct name. One of them may well be a new record for the county.

The following descriptions of the most frequently collected pest species should allow a person to determine the proper name for the specimens in each major group and to make up a guide for the quick identification of local pest species. Fifty and preferably over 100 specimens should be collected. The more specimens, the easier it is to complete the project sequence for a given community.

Projects completed:

1. Mosquitoes collected for sorting ______ (Signed) ______________________
2. State List obtained ______ ______________________
date manager, teacher, leader, parent

Table 6 . State Lists and Classical Mosquito Drawings

Region VIII State Lists

Colorado	Harmston, Fred C. and Fred A. Lawson. 1967. Mosquitoes of Colorado. USHEW, PHS, Center for Disease Control: Atlanta. 140 pages.
North Dakota	Post, Richard L. and J. A. Munro. 1949. Mosquitoes of North Dakota. N. D. Agr. Expt. Sta. Bim. Bull., 11(5):173-183.
South Dakota	Gerhardt, Richard W. 1966. South Dakota Mosquitoes and Their Control. S. D. Agr. Expt. Sta. Bull. #531. 80 pages.
Montana	Quickenden, Kenneth L. and Van C. Jamison. 1979. Montana Mosquitoes, Part 1: Identification and Biology. Vector Control Bulletin No. 1 (Revised). St. Dept. of Hlth. and Environmental Sciences: Helena. 54 pages.
Wyoming	Owen, William B. and Richard W. Gerhardt. 1957. The Mosquitoes of Wyoming. University of Wyoming Publications in Science, 21(3):71-141.
Utah	Nielsen, Lewis T. and Don M. Rees. 1961. An Identification Guide to the Mosquitoes of Utah. University of Utah Biological Series, 12(3). 63 pages.

Classical Mosquito Drawings

Old Master	Carpenter, Stanley J. and Walter J. LaCasse. 1955. Mosquitoes of North America. (1974 reprint $28.50) Univ. of Calif. Press: Berkeley. 360 pages.
California	Bohart, R. M. and R. K. Washino. 1978. Mosquitoes of California. Agr. Sciences Pub. #4084. Univ. of Calif: Berkeley 94720. 153 pages. $6.00.

Table 7. POTENTIAL PEST SPECIES OF MOSQUITOES IN REGION VIII

#	Species	Biting Period	Generations	Range (mi.)	State Frequency* CO	MT	ND	SD	WY	UT
1	Aedes campestris	Apr-Jun	2-3		3	3	2	2	2	2
2	canadensis	May-Aug	1	short	-	3	x	x	x	-
3	cataphylla	May-Jul	1	strong	2	x	-	-	1	2
4	cinereus	May-Jul	2-3	short	3	2	-	x	x	x
5	dorsalis	Apr-Nov	1/flooding	10-20	1	1	1	1	1	1
6	excrucians	Jun-Aug	1	migrate	2	x	x	x	2	3
7	fitchii	May-Aug	1		2	3	x	x	2	2
8	flavescens	Apr-Jul	1		x	3	2	3	3	x
9	hexodontus	Jun-Aug	1		2	x	-	-	3	2
10	idahoensis **	Jun-	1	several	1	1	3	x	1	-
11	impiger	Jun-	1		x	x	-	-	2	3
12	implicatus	Apr-Jun	1		3	x	-	-	3	3
13	increpitus	Apr-Aug	1		2	2	-	x	2	1
14	intrudens	Jun-Jul	1		3	x	x	x	x	x
15	melanimon	May-Sep	1/flooding	10+	2	1	-	-	1	2
16	nevadensis (comm.)	Jun-Aug	1	short	2	3	-	-	1	2
17	nigromaculis	May-Sep	1/flooding	2-5	1	1	2	2	2	2
18	niphadopsis	Apr-Jul	1	several	-	-	-	-	-	2
19	pullatus	Jun-Aug	1		1	x	-	-	2	2
20	punctor	May-Jul	1		3	x	x	-	x	-
21	sollicitans			5-20	-	-	-	3	-	-
22	spencerii **	Apr-Jun	1-3	strong	-	3	2	3	2	3
23	sticticus	Apr-May	1-2	25-30	2	2	3	3	x	3
24	triseriatus	Jun-	several	½-1	-	x	x	3	x	-
25	trivittatus	May-Aug	several	short	1	2	2	3	x	-
26	vexans	Apr-Oct	1/flooding	5-10	1	1	1	1	1	1
1	Anopheles earlei (occid.)	Apr-Sep	several		3	x	3	3	x	x
2	franciscanus	Jul-Sep			3	-	-	-	-	3
3	freeborni	Apr-Oct	several	1-2	2	x	-	-	x	2
4	punctipennis	Jun-Sep	several		2	x	x	x	x	-
1	Culex erythrothorax	Jul-Oct		short	3	-	-	-	-	2
2	pipiens	Jul-Oct	several	1+	x	x	x	3	x	1
3	salinarius				3	-	x	3	x	3
4	tarsalis	Jun-Oct	several	2-10	1	1	1	1	3	1
1	Culiseta impatiens	Apr-May	several		3	x	-	x	3	3
2	incidens	Jun-Sep	several	short	3	3	-	x	x	2
3	inornata	Jun-Oct	several		3	2	2	3	3	1
1	Coquillettidia perturbans	Jul-	1		x	x	x	3	x	x
1	Psorophora signipennis		several		3	x	x	x	x	x
39										

* State Frequency: 1 = abundant, 2 = common, 3 = fairly common,
(x) = present in state, (-) = not collected in state

** Considered one species, subspecies, and different species by various authors.

Table 8. RANKING OF MOSQUITOES IN REGION VIII BY COMPARATIVE ABUNDANCE

Regional Ranking	Species	State Ranking *						Distribution
		CO	UT	WY	MT	SD	ND	
1	*Aedes dorsalis*	1	1	1	1	1	1	plains & valleys
1	*vexans*	1	1	1	1	1	1	plains & valleys
3	*Culex tarsalis*	1	1	3	1	1	1	plains & valleys
4	*Aedes nigromaculis*	1	2	2	1	2	2	plains
5	*campestris*	3	2	2	3	2	2	plains
5	*Culiseta inornata*	3	1	3	2	3	2	plains, valleys, mtns.
7	*Aedes idahoensis*	1	-	1	1	x	3	plains & valleys
8	*increpitus*	2	1	2	2	x	-	plains, valleys, mtns.
8	*melanimon*	2	2	1	1	-	-	plains & valleys
11	*fitchii*	2	2	2	3	x	x	plains, valleys, mtns.
11	*sticticus*	2	3	x	2	3	3	plains
11	*trivittatus*	1	-	x	2	3	2	plains
13	*nevadensis (communis)*	2	2	1	3	-	-	mountains
13	*spencerii*	-	3	2	3	3	2	plains & valleys
16	*cataphylla*	2	2	1	x	-	-	valleys & mountains
16	*excrucians*	2	3	2	x	x	x	mountains
16	*flavescens*	x	x	3	3	3	[illegible]	plains
16	*pullatus*	1	2	2	x	-	-	mountains
19	*Culex pipiens*	x	1	x	x	3	x	plains & containers
21	*Aedes hexodontus*	2	2	3	x	-	-	mountains
21	*Anopheles earlei (occid.)*	3	x	x	x	3	3	valleys
21	*Culiseta incidens*	3	2	x	3	x	-	plains, valleys, mtns.
24	*Aedes cinereus*	3	x	x	2	x	-	valleys & mountains
24	*Anopheles freeborni*	2	2	x	x	-	-	plains & valleys
24	*Culex salinarius*	3	3	x	-	3	x	plains
24	*Culiseta impatiens*	3	3	3	x	x	-	mountains
29	*Aedes impiger*	x	3	2	x	-	-	mountains
29	*implicatus*	3	3	3	x	-	-	valleys & mountains
29	*intrudens*	3	x	x	x	x	x	mountains
29	*Anopheles punctipennis*	2	-	x	x	x	x	plains
29	*Coquillettidia perturbans*	x	x	x	x	3	x	plains
29	*Psorophora signipennis*	3	x	x	x	x	x	plains
34	*Aedes canadensis*	-	-	x	3	x	x	mountains
34	*punctor*	3	-	x	x	-	x	mountains
34	*triseriatus*	-	-	x	x	3	x	plains in treeholes
34	*Culex erythrothorax*	3	2	-	-	-	-	plains
37	*Anopheles franciscanus*	3	3	-	-	-	-	valleys
38	*Aedes niphadopsis*	-	2	-	-	-	-	valleys
39	*sollicitans*	-	-	-	-	3	-	plains

* State Ranking same as State Frequency on Table 7.

Table 9. TWENTY-SEVEN PEST SPECIES IN REGION VIII (TARGETS OF CURRENT CONTROL OPERATIONS)

Pest Ranking	Species	Pest Status	State Ranking					
			CO	UT	WY	MT	SD	ND
1	Aedes dorsalis	WN, V	1	1	1	1	1	1
1	vexans	WN, V	1	1	1	1	1	1
3	Culex tarsalis	WN, V	1	1	x	1	1	1
4	Aedes nigromaculis	LN	1	2	2	1	2	2
5	idahoensis		1	-	1	1	x	x
6	increpitus	WN	2	1	2	2	x	-
6	melanimon	WN	2	2	1	1	-	-
8	campestris	LN	x	2	2	x	2	2
11	cataphylla	LN	2	2	1	x	-	-
11	nevadensis (communis)	LN	2	2	1	x	-	-
11	pullatus	LN	1	2	2	x	-	-
11	trivittatus		1	-	x	2	x	2
11	Culiseta inornata	LN, V	x	1	x	2	x	2
14	Aedes fitchii	LN	2	2	2	x	x	x
17	excrucians		2	x	2	x	x	x
17	hexodontus	LN	2	2	x	x	-	-
17	spencerii		-	x	2	x	x	2
17	sticticus		2	x	x	2	x	x
17	Anopheles freeborni	LN, V	2	2	x	x	-	-
20	Culex pipiens	WN	x	1	x	x	x	x
24	Aedes cinereus		x	x	x	2	x	-
24	flavescens		x	x	x	x	x	2
24	impiger		x	x	2	x	-	-
24	niphadopsis	LN	-	2	-	-	-	-
24	Anopheles punctipennis		2	-	x	x	x	x
24	Culex erythrothorax	LN	x	2	-	-	-	-
24	Culiseta incidens	LN	x	2	x	x	x	-

State Ranking: 1 = annual pest, 2 = commonly a pest, x = can be a pest
Pest Status: LN = local nuisance, WN = widespread nuisance, V = vector

Table *10* BREEDING SOURCES COMMONLY INHABITED BY PEST SPECIES

Pest Ranking	Species	Distribution	Pest Breeding Sources Classification	Comment
1	*Aedes dorsalis*	P, V	A,B,C	*Irrigation* waste water Irrigated meadows Grassland pools Overflow pools Temporary pools
1	*vexans*	P, V	A,B	
3	*Culex tarsalis*	P, V	A,B,C	
4	*Aedes nigromaculis*	P	A,B	
5	*idahoensis*	P, V	A,B,C	
6	*increpitus*	P, V, M	A,B	
6	*melanimon*	P, V	A,B	
8	*campestris*	P	A,B	
11	*cataphylla*	V, M	B,C	*Mountain* (temporary) snow-water and woodland pools
11	*nevadensis* (*communis*)	M	B	
11	*pullatus*	M	B	
11	*trivittatus*	P	B	Overflow pools
11	*Culiseta inornata*	P, V, M	B,C	Permanent pools
14	*Aedes fitchii*	P, V, M	A,B,C	Irrigation
17	*excrucians*	M	B,C	Mountain
17	*hexodontus*	M	B	
17	*spencerii*	P, V	A,B	Irrigation
17	*sticticus*	P	B	Overflow pools
17	*Anopheles freeborni*	P, V	C	Marshes
20	*Culex pipiens*	P	C,D	Marshes & containers
24	*Aedes flavescens*	P	A,B	Irrigation
24	*cinereus*	V, M	B,C	Mountains
24	*impiger*	M	B	
24	*niphadopsis*	P, V		
24	*Anopheles punctipennis*	P	C	Marshes
24	*Culex erythrothorax*	P	C	
24	*Culiseta incidens*	P, V, M	B,C	Mountains
27				

Distribution: P = plains, V = valleys, M = mountains (above 6000-7000 ft)

Pest Breeding Source Classification: A = irrigation related
B = temporary natural pools
C = marshes
D = containers, tires & junk

Project II-3.2a Recognizing the Two Most Abundant Species

These two species make up about 60% of collections on the plains and valleys. Both are medium sized mosquitoes that can emerge in enormous numbers from irrigation waste water, irrigated meadows, overflow pools and other temporary pools. They have an average maximum flight range of over 10 miles across favorable terrain.

1. Aedes vexans

Examine the group sorted out by groups 2, 3, 6a (Table 11):

2. white tarsal bands present
3. tarsal bands end at the joint between segments
6. narrow tarsal bands
a. tip of abdomen pointed = Genus Aedes

Turn the specimens over and on the upper surface of the abdomen look for a V-shaped notch in the middle of the white bands. It is usually there. This character confirms the group is "V" for vexans. Individual specimens may vary in size and intensity of color, however, the bright white to pale narrow bands on the tarsi of any Aedes is the easiest character to sort with once you know Aedes vexans. Set aside any specimens in the group that do not conform to Aedes vexans. They may be other species or damaged specimens you will later be able to recognize with more experience.

2. Aedes dorsalis

Examine the group sorted out by groups 2, 4a (Table 11):

2. white tarsal bands present
4. tarsal bands cover both sides of joint
a. tip of abdomen pointed = Genus Aedes

This group of Aedes can contain three species. All undamaged specimens carry a longitudinal stripe of white scales on the upper (dorsal) surface of the abdomen. Those individuals that show wing vein 3 much darker than vein 2 or 4 are Aedes dorsalis. They vary widely in the color of the thorax and in the amount of white scales remaining on the body. The tarsal bands and the dark scales on vein 3 (ends at the tip of the wing) are good recognition characters.

Set aside the remaining specimens from the dorsalis group. Two other species may be present in the group, 5. campestris and 9. melanimon, that will be separated later.

Projects completed:

1. Know vexans and dorsalis ______ (Signed) ____________________
2. Know the two most abundant species in my study area ______ ____________________

date manager, teacher, leader, parent

Table 11. Characters to Use in Sorting Pest Mosquitoes into Groups

The characters used to sort biting mosquitoes fall into two groups: Those that can be seen by the unaided eye or with the help of a 10X hand lens and those that require a 30X to 50X microscope. The plains and valley pest species are much better marked than the mountain species. The plains and valley species also occur in large mixed populations.

The easiest characters to use when sorting with a 10X lens and you do not know the species are listed below:

1. Tarsal bands. Look for white bands or rings on the hind tarsi (lower leg segments) and sort the mosquitoes by:

   a. White bands absent . . . . group 1
   b. White bands present . . . . group 2

2. Location of tarsal bands. Sort group 2 with tarsal bands by mosquitoes on which:

   a. Band ends at the joint between segments . . . . . group 3
   b. Band covers both sides of the joint . . . . group 4

3. Width of tarsal bands. Sort group 3 with tarsal band ends at the joint by:

   a. Wide bands (cover more than 1/4 of segment) . . . group 5
   b. Narrow bands (cover less than 1/4 of segment) . . group 6

4. Tip of abdomen. Sort each group (1, 4, 5, and 6) by:

   a. Tip of abdomen pointed = Genus *Aedes* . . . . group a
   b. Tip of abdomen rounded . . . . group b

5. Proboscis banded. Look for a white band or ring near the middle of the proboscis in each group (1, 4, 5, and 6) and sort by:

   a. Proboscis with white band . . . . group c
   b. Proboscis without white band . . . . group d

6. Maxillary palpus. Look for a palpus on either side of the proboscis in each group (1, 4, 5, and 6) and sort by:

   a. Palpi as long as proboscis = Genus *Anopheles* . . . group e
   b. Palpi much shorter than proboscis . . . . group f

After finishing a sort, check each group to see if all the mosquitoes in it look alike. If not, choose another character and again sort. When finished sorting, count the number of specimens in each group to determine their pest status.

Other characters used to identify the less frequently collected pest species as well as many of the mountain species require a 30X to 50X microscope. For these species it is also helpful to mount the specimens so the top and side views can readily be observed (Project II-B.2f).

Project II-B.2b Recognizing the Second Two Most Abundant Species

Both are medium sized mosquitoes that also emerge from irrigation waste water, irrigated meadows, overflow pools and other temporary pools but in fewer numbers than the first two species. They have an average maximum flight range of less than 10 miles across favorable terrain. Together the 4 species make up about 70% of collections from the plains and valleys.

3. Culex tarsalis

Examine the group sorted out by groups 2, 4bc (Table 11):

2. white tarsal bands present
4. tarsal bands cover both sides of the joint
b. tip of abdomen rounded
c. proboscis with white band

The specimens with white bands on the proboscis and tarsi are members of the only pest species of Culex with brightly marked tarsal segments. Culex tarsalis is the species collected alive for encephalitis surveys. Set aside any specimens that do not conform to Culex tarsalis .

4. Aedes nigromaculis

Examine the group sorted out by groups 2, 3, 5ac (Table 11):

2. white tarsal bands present
3. tarsal bands end at the joint between segments
5. wide tarsal bands
a. tip of abdomen pointed = Aedes
c. proboscis with white band (and/or a longitudinal line of yellowish scales on the upper surface of the abdomen)

The band on the proboscis is sometimes missing. Therefore a check of the scales on the abdomen is needed. If the abdomen is covered with yellowish scales rather than the line of yellowish scales, the specimen is Aedes flavescens, the yellow Aedes, rather than nigromaculis, the black blotched (spotted or speckled) Aedes.

Projects completed:

1. Know Culex tarsalis and Aedes nigromaculis ______ (Signed) ______________________
2. Know the sedond two most abundant species in my study area ______ ______________________

date manager, teacher, leader, parent

Project II-B.2c Selecting Sight Recognition Characters for Rapid Sorting

Rapid sorting of pest species demands that the specimen is recognized at sight rather than having to "key it out" using several individual characters. Gaining this skill is worthwhile. It improves the quality and quantity of information for control purposes. Even in an entire state the number of pest species in any one year tends to be only a few of the potential pest species. Even fewer would be found in any one community.

Ranking of States by the Number of Pest and Potential Pest Species

	Number of Species					
Species	CO	UT	WY	MT	SD	ND
Abundant	7	6	6	5	3	3
Common	10	12	8	6	2	6
Ranking by Pest Species	17	18	14	11	5	9
Fairly common	13	8	6	7	11	3
Ranking by Abundance of potential pest species	30	26	20	18	16	12

Since different people tend to be impressed by different characters, each person should make up and use their own memory guide of recognition characters for rapid sorting as they learn to recognize each species, making additions as needed. If, as is the case in some communities, the top 4 are the only pest species to consider, the following set of recognition characters is one example:

1.	Tarsal bands very narrow	*Aedes vexans*
2.	Tarsal bands cover joint	*Aedes dorsalis* group
3.	Abdomen rounded	*Culex tarsalis*
4.	Tarsal bands wide	*Aedes nigromaculis*

Sorting speed is developed by practice and by setting aside the few odd specimens for later. If these "few" become too many, you need to learn to recognize another pest species.

You are now ready to sort into 5 groups at one time instead of into 2 groups. Four groups are the species you recognize at sight and the fifth group is the "others".

Projects completed:

1. Recognition characters selected for the four most abundant species in my study area ______ (Signed) ____________________
2. Explain the variation in the number of pest species between states ______ ____________________

date manager, teacher, leader, parent

Project II-B.2d Recognizing the Second Four Most Abundant Species

The *Aedes* species 6 and 7 are less abundant as they have but one generation a year instead of a new generation with each flooding.

5. *Aedes campestris*

The remaining specimens from the *dorsalis* group that have a uniform mixture of white and dark scales on the wing veins must now be sorted by the predominate color of the scales on the front edge of the wing.

a. white scales predominate = *Aedes campestris*
b. dark scales predominate = *Aedes melanimon*

6. *Aedes idahoensis*

Examine the group sorted out by groups 1a (Table 11). Sort out those specimens on which the alternate wing veins are covered with white and dark scales rather than being uniform in color. *Aedes idahoensis* is more abundant in the four mountain states than its very close relative *Aedes spencerii*. A first approximation in separating the two is to sort by the marking on the upper surface of the abdomen:

a. white cross bands = *idahoensis*
b. longitudinal white stripe = *spencerii*

7. *Aedes increpitus*

Examine the group sorted out by groups 2, 3, 5ad (Table 11). This group can contain two plains and valley species with white scales on the abdomen. For any with yellow scales check #4. *Aedes nigromaculis* . Sort the white specimens by the number of white scales on the base segment (the tori) of the antenna. Those with a few or no scales on the dorsal surface of the tori are *Aedes increpitus*. Those specimens with many scales on the dorsal surface of the tori are *Aedes fitchii* which also have a mesonotum (dorsal surface between the wings) with a broad, light reddish brown median stripe. In mountain collections, *Aedes excrucians* will also be in this group. This species has the most unusual claws. The claw is similar in appearance to the side view of your hand when only the thumb and first finger can be seen held parallel to each other with the space between equal to the width of the thumb.

8. *Culiseta inornata*

Examine the group sorted out by groups 1b (Table 11). This group can contain several species. *Culiseta inornata* will have pale scales on the wings and legs and, in general, be in greatest number. *Culex pipiens*, with coarse brassy scales on the mesonotum, will also sort out in this group.

Projects completed:

Know the second four
most abundant species
in my study area ______ (Signed) ______________________
date manager, teacher, leader, parent

Project II-B.2e Recognizing the Second Eight Most Abundant Species

Three of these species have already sorted out:

9. *Aedes melanimon* with 5. *campestris*
10. *Aedes fitchii* with 7. *increpitus*
11. *Aedes spencerii* with 6. *idahoensis*

The remaining five species in this last group of eight are all members of the difficult group known as the black or dark legged *Aedes*. as are *spencerii* and *idahoensis*.

12. *Aedes trivittatus*
13. *Aedes sticticus*

Again examine the group sorted out by groups 1a (Table11). Those specimens from the plains and valleys with the nesonotum showing a pair of broad yellowish-white to brassy yellow stripes separated by a brown stripe of about the same width will be *trivittatus*. *Aedes sticticus* will show a mesonotum with a median strip of darker scales boardered by grayish (not yellowish) scales.

14. *Aedes nevadensis* (*communis*)
15. *Aedes cataphylla*
16. *Aedes pullatus*

These are the mountain black legged *Aedes*. They bite any time of day it is warm enough for flight. Fortunately they have but one generation per year.

The separation of these last three species and the initial identification of other pest species requires a 30X to 50X microscope and a taxonomic key to the species of the state in which they were collected. When a species has been firmly fixed in mind on a cluster of characters, that are too numerous and require an excessive amount of space to use in a taxonomic key, then many other species can also be identified with the aid of a 10X lens.

The sort and count method has its main virtue in training a person to quickly locate easily observable characters with which to rapidly sort and identify groups of specimens of the most common pest species encountered in control operations. It cannot replace the more careful process of mounting and studying individual specimens for the less abundant species.

Projects completed:

Know the abundant
pest species in
my study area ______ (Signed) ______________________
date manager, teacher, leader, parent

Project II-B.2f Labeling and Preserving Pest Specimens

Those species that together make up 90 to 95% of the total specimens collected are the pest species.

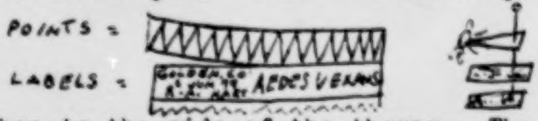
1. Confirm identifications of the sorted groups by:

   a. Comparing with descriptions given in the State Lists.
   b. Comparing with reliably identified specimens.
   c. Taking specimens to a person who knows the pest species.

2. Preserve specimens for identification and reference by:

   a. Small containers. Mosquitoes can be held indefinitely in small containers if kept dry. If they become too dry to work with without breaking up, place a moist paper or cloth over the top of the container to "relax" them. Do not get the specimens wet. Ship such a container only with sufficient packing to prevent the specimens from moving about.

   b. Pointing. (For rare and valuable specimens) Cut points from file card stock. Insert a pin through the wide end of the point to a uniform height on the pin. Touch the narrow point to clear finger nail polish and then to the side of the thorax. The legs can either be positioned down or laid on top of the point. Store the pinned specimens in a secure box with a soft bottom to accept the pins.



   c. Dry mounting. (For abundant pest species) Durable dry mounts are made by lightly pressing not entirely dry specimens between a sheet of light clear plastic sheeting (sandwich bags) and Magic Tape or clear Contact shelf paper. Position the specimen on the sticky surface such that a dorso-lateral view (or other desired feature) is seen through the clear plastic. The electrostatic charges on the plastic tend to reposition parts of the specimens. With a little practice over half of the mounts will make good reference specimens. Trim the mount and fasten to a file card. Several can be fastened to one card or poster. Record collection and identification information on the card.

3. Make a guide for rapid sorting of your pest species using one or a combination of:

   a. Specimens preserved from above.
   b. Copies of drawings such as those in Carpenter and LaCasse (Table 6).
   c. Sight recognition characters from the sorting projects.

Projects completed:

		(Signed)
project or report title	date	manager, teacher, leader, parent

Project II-B.3 Making Adult Mosquito Surveys

Control operation techniques must be done with a minimum of time or they are not practical. Several types of observations are made as a basis for selecting optimum control strategies.

Landing counts. Move briskly to your selected site. Count the number of mosquitoes that land on the observable part of your body or work with a partner and count the number landing on the partner. Stand or sit in the same manner for each counting period. Either the number of mosquitoes landing in a fixed time (½ to 5 minutes) or the number of minutes for a fixed number of mosquitoes to land can be recorded. This method of observation is fast and inexpensive. If the same people wearing the same type of cloths participate, results are also reasonably reproducible. Counts are typically made from dusk to about 1 hour after sundown. Leave the site and return for repeated counts at one site.

Landing/biting collections. Maintain the above conditions and collect all the mosquitoes possible in the assigned time or record the amount of time needed to collect a fixed number of mosquitoes. A battery powered collector is needed for high populations (Project II-B.1b - d).

New Jersey light trap. These are typically operated all night for state or district surveys. You are responsible for removing the collection each morning and storing it or of sorting out the mosquitoes and when qualified identifying them. The agency providing the trap will assist in locating it and provide instruction for its operation (Projects I-A and I-C).

CDC light trap. This trap operates as above but obtains live specimens for encephalitis virus surveys or research projects. Light traps collect both males and females (Projects I-A and I-C).

Resting site. During the day mosquitoes must find shelter. For several species, the number found per room, per out building, or per culvert is a meaningful observation. Several species overwinter in rock piles and animal dens.

Projects completed:

1. Repeated observations at one site ______ (Signed) ____________________
2. Several sites/one night ______ ____________________
3. Several nights/one site ______ ____________________
4. Report including variation between observations (See Part III-A) and the possible causes of this variation ______ ____________________

date manager, teacher, leader, parent

Project II-B.3a Making Species and Population Surveys

1. Select the area to be studied.
2. Select the purpose of the survey:
    a. pest species in the area
    b. all species in the area
    c. number of biting females at selected sites or times
3. Select the time period of the study:
    a. days or nights
    b. weeks or months
    c. seasons
4. Select the method of observation:
    a. landing counts
    b. landing/biting collections
    c. light trap
    d. resting site
5. Select the time period for each observation:
    a. minutes or hours
    b. all night
6. Select the number of observation periods: one or more
7. Select the number of observation sites: one or more

- - - - - - - - - - - - - - Examples -

Species survey. Using killing vials or other collectors, make collections for a minimum of 30 minutes or 100 specimens at each different type of breeding and resting habitat on a minimum of two nights. Sort specimens and identify (Project II-B.2).

Population survey--seasonal. Select a representative site in the area and schedule a minimum of one observation night per week for the biting season. Record counts or sort specimens collected and record the number of each species for each observation period.

Population survey--area. Select several sites in the area that can either be reached in one night between dusk and about one hour after sun set or have helpers at each site. Record counts or sort the mosquitoes collected and record the number of each species for each site. Also see Part III-A for sampling designs and count interpretation.

Projects completed:

1. Species survey ______ (Signed) ______________________
2. Population survey ______ ______________________
3. Report relating survey results to human activities and complaints ______ ______________________

date manager, teacher, leader, parent

Project II-B.3b Making an Adulticiding Quality Control Survey

Quality control surveys have many of the same requirements as do research projects. Two different questions can be asked:

1. What real effect did an adulticiding application have on the population of biting mosquitoes in the treated area (and outside)?
2. What portion of the mosquitoes in the treated area were killed?

The first question indicates the value of the treatment to the community. The second indicates the effectiveness of the application. The questions can be answered by using modifications of population surveys (Project II-B.3a). A quality control survey requires careful planning and a team of observers or collectors, a good group project.

1. Seasonal quality control survey method: (Also see Part III-A)

   Site selection. Select two types of sites: those that will be treated and those that will not. One way to do this is to establish sites in the protected area and others in the outlying area that will be subject to the same weather conditions.

   Timing of observations. Make counts or collections nightly before and after the application as well as on the night of application shortly before and ½ to 1 hour after application to obtain the most useful information. A 7 day series is optimal.

   Conclusions. Plot results on a graph and determine the percent reduction in the treated area for each 24 hour period after treatment. What percent were killed (count at ½ to 1 hour after application) and how long did it take for the population to return to pretreatment levels?

2. Area quality control survey method: (Table 12)

   Site selection. Select the two types of sites on opposite sides of the path the spray truck will travel. Ideally the wind will be blowing directly across the street.

   Timing of observations. Make counts or collections shortly before application and again ½ to 1 hour after treatment at the same sites (before new mosquitoes can fly in).

   Conclusions. What percent were killed? What application and environmental factors may have influenced the counts?

Projects completed:

1. Project planned ______ (Signed) ______________________________
2. Observations made ______ ______________________________
3. Report finished ______ ______________________________

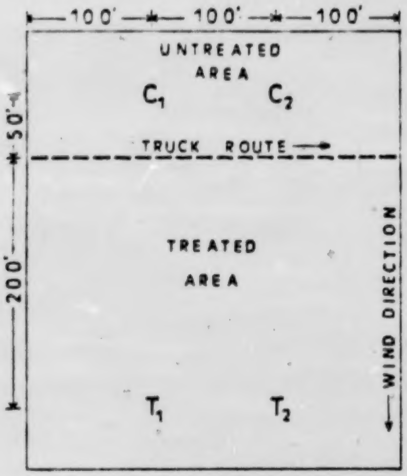
date manager, teacher, leader, parent

Reference:

American Institute of Biological Sciences. January 1977. Mosquitoes, Black Flies, Midges and Sand Flies. Volume VIII of Analysis of Specialized Pesticide Problems, Invertebrate Control Agents, Efficacy Test Methods. EPA 540/10-77-006. 52 pages.

Table 12. Layout, Terms and Calculations for Area Quality Control Survey

Layout. The following layout provides fixed distances between observation sites and the truck mounted applicator route. They can be changed to match features in your community such as the size of city blocks or the location of alleys such that sampling does not require you to enter private property.



Observation sites

C = check site

T = treatment site

Percent control. The percent control is most easily estimated * by using the before and after treatment counts in the treated area.

$$\%\ \text{Control} = \left(1 - \frac{T_a}{T_b}\right) \times 100$$

T_a = counts in treated area after treatment
T_b = counts in treated area before treatment

A better estimate is to include the effect of varying flight activity during the night based on the untreated or check area.

$$\%\ \text{Control} = \left[1 - \left(\frac{T_a}{T_b} \div \frac{C_a}{C_b}\right)\right] \times 100$$

C_a = counts in check area after treatment
C_b = counts in check area before treatment

A best estimate includes the variance (Project III-A).

Reference:

Sjogren, R. D. and A. M. Frank. 1979. Effectiveness and cost of nonthermal Resmethrin aerosols for control of Aedes mosquitoes in wooded areas. Mosquito News 39(3):597-604.

* The difference between before and after treatment landing/biting counts is assumed to be due to having killed mosquitoes. The application may also have repelled others to fly away or to not fly at all until after the second count. Only a dead mosquito in hand is a confirmed dead mosquito.

II-C. Know Your Mosquito Breeding Sites

Mosquitoes breed in much smaller spaces than the area they cruise about looking for a blood meal. This makes larval control easier than adult control. Further the larvae are poor swimmers. They must come to the surface to breath air. Rain or wave action will drown them. Cattails will trap them. To survive they must live in shallow (generally 4 inches or less) protected areas free from fish and other predators. Each species has a most favored larval habitat from tree holes and tires to natural temporary pools and stagnant irrigation waste water.

The ultimate control option is to alter or remove those habitats that produce mosquitoes. This is not always necessary or even possible in practice, but knowning where the breeding habitats are that produce your pest mosquitoes is both possible and necessary for optimum management decisions.

The first step is to find the breeding sites by dipping for the larvae and pupae (wigglers and tumblers). A variety of things work well such as a white enamal dipper, an aluminum or plastic shallow square cake pan, or a shallow plastic bowel. Experience will show the need for a quick dip without casting a shadow. A change of light or motion or a loud step will send the larvae to the bottom in a panic. Vary your dip technique from a simple rapid submergence to a shallow sweep. Use the techniques that are best for your species. Plot each breeding site on a large scale operations map (16 inches per mile, Project II-A.2). Take some of the larvae home to raise out as adults that can be identified.

The second step is to classify each breeding site by a priority for the control of breeding. As you study the site, be thinking of ways to alter the habitat in such a way that the result is also a long term improvement in wildlife production, in agricultural productivity, or in aesthetic value. Convenient sites make for good projects on mosquito productivity and on the sequence of species produced during the breeding season. Also be on the watch for predators in the area. Learn to recognize the type of habitat each of your pest species prefers. Highest priority for control goes to those sites that are big producers of the worst pest species. This may be a 5 gallon pail outside your window.

When access to property is not permitted, breeding sites can be inferred from aerial photos and from light trap collections at the property line. Male mosquitoes come to light traps only from nearby breeding sites that are generally down wind from the trap.

CAUTION: Snakes, Gates, Poison Plants, Bogs and Hogs. Respect private and public property rights. Do not enter unfamiliar areas alone. Wear suitable protective clothing. Always ask permission. Ask about livestock. Close securely all gates you open. Let the owner know when you leave. Good public relations is an absolute necessity.

Project II-C.1 Making a Larval Mosquito Breeding Site Survey

1. Select the area to be studied.
2. Select the purpose of the survey:
    a. confirm which wet areas are breeding sites
    b. number of larvae per area
    c. determine species in area
3. Select the time period of the study: day, week, month, season
4. Select the method of sampling:
    a. dipper, bowl, or pan
    b. hose and suction bulb
5. Select the number of observations per site.
6. Select the method of recording data:
    a. notebook
    b. maps (Project II-A.2)

- - - - - - - - - - - - - - - EXAMPLES -

1. Breeding site survey: Dip samples from each body of water in the area including pools, junk, and tree holes. Plot on your large scale map (16 inches/mile) each pool with wigglers. In your notebook, record the water source, type of pool, and how it drains.

2. Population survey: As in #1, however, this time take a minimum of three dips and count the larvae and pupae. With practice you can also record if the breathing tube is:
    a. missing = Anopheles, permanent pool mosquitoes
    b. very long and thin = summer and fall mosquitoes
    c. intermediate = Aedes, spring and flood-water mosquitoes

3. Species survey: Collect 20 to 100 larvae and pupae from each different type of breeding habitat. Hold the pupae in clean water (no chlorine). Hold the larvae in pond water and add a few grains of yeast or dog buiscut every other day. Allow adults to emerge and feed on a sugar cube or boiled raison for 24 hours before killing. Sort and identify (Project II-B.2).

Projects completed:

1.	Area described	______	(Signed) ______________________
2.	Permission to enter	______	______________________
3.	Breeding site survey	______	______________________
4.	Population survey	______	______________________
5.	Species survey	______	______________________
6.	______________________	______	______________________
7.	______________________	______	______________________
	report title	date	manager, teacher, leader, parent

Project II-C.1a Building Two-Chambered Cages for Emerging Adults

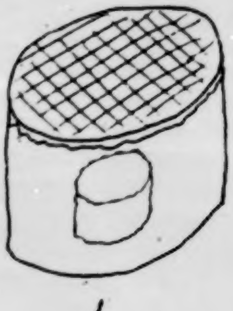
Simple to elaborate cages can be made to hold pupae and larvae for the emergence of adults. Pupae are best as they do not need to be fed. Fourth instar larvae need little if any feeding. The smaller larvae must be fed and are also more difficult to bring in from the field without drowning. In a mixed sample the larger larvae will suppress the smaller ones. Unless you plan to rear out all the specimens there is no need to feed after pupae appear.

Use glass or plastic for the lower part which is the pool for the larvae and pupae. The upper part can be made of glass, plastic, cardboard, pasteboard or tin can. A mesh covered opening in the top of the upper chamber keeps the humidity down for the adults and permits feeding them from outside the cage.

1. Pool within a bottomless cover chamber. Place a cover chamber over the sample. A tin can with both ends cut out and covered with mesh works well. Dead adults can be obtained by lifting and moving the cover a short distance. Use only about 1/4 inch of water for a pupal sample so all the water will evaporate shortly after the adults emerge.

2. Pool slides out bottom of cover chamber. As above, except make a bottom plate with a hole in the center of the same size as the pool container. Now the pool can be lowered through the plate leaving the adults in the upper chamber. Any clear material (drinking glass or small jar) can be used for the top chamber.

3. Pool below bottom of cover chamber. As above, except stack the three parts one on top of the other. A cone can be added to prevent adults from falling into the pool. Almost any size and shape of small glass or jar can be used for the chambers.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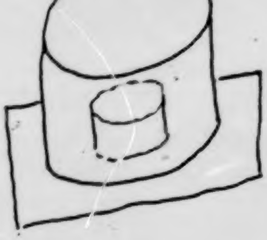
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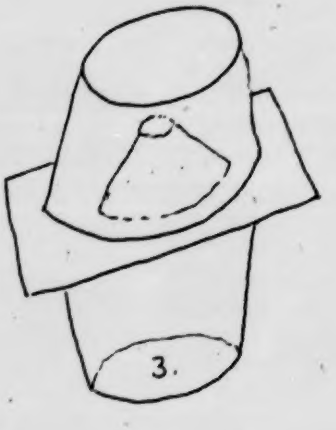

3.

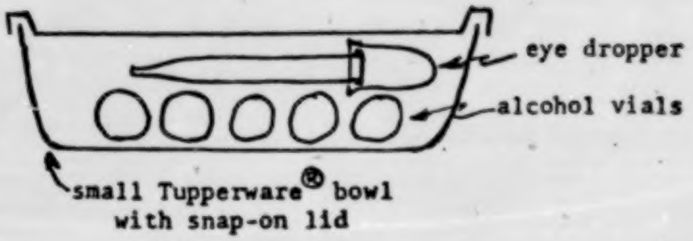
Projects completed:

1. One emergence cage ______ (Signed) ______________________________

2. Set of _____ cages ______ ______________________________

date manager, teacher, leader, parent

Project II-C.1b Making a Pocket Larval Collecting Kit



1. Obtain a small Tupperware bowl with a snap-on lid.

2. Obtain an eye dropper. A plastic eye dropper can be trimmed so the opening is large enough to readily accept mosquito larvae.

3. Fill small vials with alcohol (ethyl or isopropyl).

4. Drop a numbered piece of paper into each vial.

5. Fasten a note card to the bowl lid with the same sequence of numbers in the vials, if desired.

6. Place the eye dropper and vials in the bowl and snap on the lid.

7. To use, dump the vials into a pocket and use the bowl to dip for larvae.

8. Use the eye dropper to transfer larvae to vials after pouring most of the water out of the bowl to restrict the larvae from moving,
   or
   pour almost all the water out of the bowl, add the alcohol from one vial, and then transfer the dead larvae and alcohol to the vial. (Fill the vials full of liquid as any air bubbles will pound the larvae to pieces.)

9. Record the collection site on the note card or in your field record book.

Project completed ______ (Signed) ________________________
date manager, teacher, leader, parent

Project II-C.2 Classifying Breeding Sites by Priority for Control

1. Complete a breeding site survey for the area (Project II-C.1).
2. Plot and number all suspected and confirmed breeding sites on operations maps (Project II-A.2 and Figure 6).
3. Record the source of water for each site and how it drains.
4. Classify each site as permanent = more than 3 months
   semi-permanent = 1 - 3 months
   temporary = 1 - 3 weeks
5. Determine the size of breeding area for each site. Exclude open water over 4 inches deep in clean sided pools large enough to have wave action or which contain fish.
6. Record the distance of each site to the nearest protected area.
7. Assign priorities for control by one or both methods:
   - A. Type, size, and location of confirmed breeding sites
     1. First priority to sites in and close to protected areas that can be eliminated with simple or no equipment.
     2. Second priority to sites requiring the use of readily available equipment or techniques located within and near the protected area (¼ to ½ mile).
     3. Third priority to sites requiring cooperative action to plan, finance and carry out control options.
   - B. Site productivity and species (Projects II-B.3a and II-C.1)
     1. First priority to highly productive sites of the most pestiferous species in and within ¼ to ½ mile of the protected area that can be eliminated with readily available equipment or techniques.
     2. Second priority to productive sites as above which require cooperative action to plan, finance and carry out management options.
     3. Third priority to extending the barrier zone as time and funds permit and as control surveys indicate are needed.
8. Design a form to tabulate the information used in assigning priorities for the control of your area breeding sites.

Projects completed:

1. Priority tabulation form designed ______ (Signed) ______________________

Priorities assigned for study or control area based on:

2. Type, size, location ______ ______________________
3. Productivity, species ______ ______________________
4. ______________ ______ ______________________
   report title — date — manager, teacher, leader, parent

II-D. Know Your Management Options

Several of the projects in which you learn to know your mosquitoes and their breeding sites let you practice making decisions based upon your own judgement. Most of the projects under management options involve making judgements based on available facts and observations. There are no preset answers to the questions of when and how to apply management options. Each breeding site must be considered separately with respect to the problem it presents to the community.

An experienced mosquito district manager can evaluate most breeding sites and recommend an optimum strategy within one season. Other sites require several years to resolve all the conflicting economic, environmental, and management problems. Only then can constructive measures be taken to reduce mosquito production without creating another set of problems.

The following projects are basically for communities that do not have organized mosquito control districts. These communities must start from the beginning. After the simpler breeding sites are under control, the remaining sites will be comparable to those found in organized districts that require long term study and management. All communities, organized or not, can use citizen assistance in resolving the major breeding sites. An involved, informed community tends to seek out the optimum mix of management options.

Regardless of the type of management options exercised in a community, the projects provide for experience in making decisions in environmental management. Even in communities in which there is no need for an organized program to manage mosquitoes, there still remains one practical goal other than environmental education and recreation: vector monitoring. The probability of a human case of encephalitis or a dog with heartworms is directly related to the number of carrier mosquitoes, birds, dogs, and humans living together.

Any number of studies and recommendations can be made for mosquito control, however, there is but one optimum mix of management options when the time comes for community action. That mix is usually unique as it is rare for two communities to have (or preceive to have) the same problems even with the same species of pest mosquitoes.

Before action is taken, the nature of the problem should be fairly evident from adult mosquito, breeding site, and human exposure surveys. Additional current monitoring is needed for proper use and timing of short term pesticide options.

Review each site for viable options and then group sites by similar options. Many sites with low productivity need no attention other than periodic monitoring. Do not pick an option and then try to fit it to all sites. A classical example is the community that buys a fogger to routinely kill mosquitoes raised in a neighboring community, a never-ending self-defeating battle. Once resistance to the spray develops, the community has lost a valuable option against the sporadic appearance of disease carrying mosquitoes.

Many of the projects should be repeated on an annual basis. Examples are projects that collect and remove water holding rubbish each spring, that determine current attitudes and economics of the community, that record changes in breeding habitat, in land use and in the effect of past control measures. Which are worth continuing under present conditions (including the foreseeable future)?

Project II-D.1 Designing Public Education Leaflets (For the Management of Small Breeding Sites)

A popular design for mosquito control leaflets is the standard 8½ by 11 inch page folded into thirds. This produces 6 panels of which 2 or 3 can be combined on a side. Examples are included in the following pocket page (Figure 9). A separate leaflet must be designed for each audience and purpose.

1. Design a front panel for your community.
2. Write a panel on your species of nuisance and vector mosquitoes.
3. Write a panel on their breeding places.
4. Write one or more panels on what the general public can do to reduce mosquito breeding.
5. Write a panel on what the general public can do for protection from mosquito bites.
6. Prepare a general public leaflet for distribution in your community on mosquitoes, their production and control.
7. Obtain a sponsor for the cost of reproducing your leaflet.
8. Prepare a breeding site survey leaflet for distribution to home owners instructing them where to look for breeding sites. Include a panel for a sketched map of their property on which to draw in breeding sites they cannot control themselves. If assistance is available, include a statement help is available to do the survey if they need it.
9. Prepare a report on the number of properties that are and are not breeding mosquitoes and on the types of sites that need community assistance.

Projects completed:

		(Signed)
project or report title	date	manager, teacher, leader, parent

Contents of Pocket Page

1. Controlling Mosquitoes at Home and on the Farm

   Montana Department of Health and Environmental Sciences
   Helena, Montana

2. Mosquitoes

   Cooperative Extension Service
   Utah State University, Logan

3. Mosquito Control in and around Homes and Farmsteads

   Cooperative Extension Service
   South Dakota State University, Brookings

4. We Need YOUR Help to Control Mosquitoes

   Tri-County District Health Department
   Adams, Arapahoe, Douglas Counties, Colorado

5. Mosquitoes

   Concession Supply Company
   Toledo, Ohio

6. Mosquito Control

   Cooperative Extension Service
   (and Colorado Department of Health)
   Colorado State University, Fort Collins

Figure . Mosquito Control Leaflets, Examples

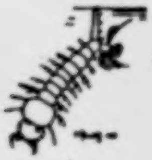
MOSQUITOES

- A PUBLIC NUISANCE
- A HEALTH HAZARD

Any standing water can produce mosquitoes in approximately 10 days. Check your premises, eliminate unnecessary standing water. If you require assistance, call your MOSQUITO ABATEMENT DIST.

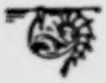
HELP US BREAK THIS CYCLE:

EGG RAFT

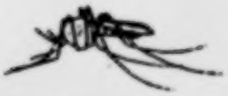


LARVA

PUPA



ADULT



1. THE EGG is laid on water or on damp ground where water will later cover it.
2. THE LARVA feeds on tiny particles of plant and animal matter in the water. This stage is known as the "wiggler" and must have water to live.
3. THE PUPA is a nonfeeding stage in the water during which the adult mosquito develops inside the pupal skin. It is known as "tumbler."
4. THE ADULT searches for animal blood to mature its eggs. Several blood meals may mature several batches of eggs. Each batch may contain 150 eggs.

Concession Supply Company
Toledo, OH 43623

SERVICE IN ACTION
COLORADO STATE UNIVERSITY EXTENSION SERVICE

Mosquito control

Ted Davis and
William M. Hantsbarger[1]

no. 5.526

Quick Facts

Several procedures will aid in the control of mosquitoes, including elimination of unnecessary standing water, good water management practices, use of organophosphate insecticides, emphasis on larval control programs and elimination of breeding sites, and use of personal repellents.

All insecticides are to be considered hazardous, and directions and precautions on labels should be read and carefully followed; all insecticides should be stored in their original containers; all insecticides should be kept out of the reach of children.

Chemical control of adult mosquitoes can be obtained by fogging, spraying or mist blowing, dusting, ultra low-volume ground applications, and aerial applications.

Chemical control of mosquito larvae can be done by ground or aerial applications to breeding areas.

Mosquitoes can be a vexing and a serious problem in Colorado. In the home, about the yard and in public parks, they can interfere with human chores and spoil enjoyment of leisure time. When mosquitoes are abundant, they reduce the efficiency of farm workers. Their persistent attack can cause farm animals to lose weight. Some mosquitoes transmit diseases, such as encephalitis.

There are several methods by which mosquitoes can be controlled. The general procedures listed below are significant in controlling mosquitoes:

—Unnecessary standing water and containers that will hold water on the premises should be eliminated.

—Good water management in irrigation practices should be exercised so as not to contribute to the amounts of standing water.

—Only properly registered insecticides, such as Baytex, Dibrom or Malathion, should be used in control programs. Malathion is most readily available and the least hazardous for individual home owners to use in ridding their yards of adult mosquitoes.

—Municipal or county control programs should emphasize larval control and the elimination of breeding areas. Mosquito control with insecticides is most effective and efficient when directed at the larvae. Adulticiding should be used only as a supportive measure to a larval control program.

—Personal protection can be gained by using any of the common commercial repellents. These repellents should be used carefully near the face. They can be applied to clothing for added protection. Repellents should be applied to children by an adult following the directions on the label.

All insecticides are to be considered as hazardous. Directions appearing on the label should be read and carefully followed, using caution when mixing or spraying insecticides. After using insecticides, a person should wash with soap and water and change clothes as soon as possible if skin and clothing have become contaminated. All insecticides should be stored in their original containers and kept out of the reach of children.

Pest mosquitoes are most closely associated with poor water management in irrigated areas. Areas that retain water one week after irrigation will produce large numbers of mosquitoes. The eggs of these species remain viable for several years in the soil. As these soils are flooded by irrigation or excessive precipitation, the eggs hatch.

Water management with close surveillance and treatment of breeding habitats are essential in controlling these species. Sprays and granular insecticides are best suited for this treatment. Insecticide restrictions listed above are applicable here.

Chemical Control of Adults

Fogging—Fogging will give temporary relief when mosquito populations are intense. It must be repeated often.

Dibrom 14 (Naled)*

1) Add 2 quarts of Ortho additive (anti-sludge agent) to empty mixing tank.

2) Add 1½ gallons (8 pounds) of naled concentrate and stir.

3) Add fuel oil to total volume of 100 gallons and stir for 5 minutes before using.

Fenthion 93% (Baytex)*

1) Add 3-6 pints of concentrate to 100 gallons of oil and stir.

---

[1] *Ted Davis, vector control specialist, Colorado Department of Health, and William M. Hantsbarger, CSU extension associate professor, entomology (revised 10/1/78)*

Issued in furtherance of Cooperative Extension Work in Agriculture and Home Economics, Acts of May 8 and June 30, 1914, in cooperation with the United States Department of Agriculture. Lowell Watts, Director of Extension Service, Colorado State University, Fort Collins, Colorado 80523. By law and purpose, the CSU Cooperative Extension Service is dedicated to serve all people on an equal and nondiscriminatory basis.

To simplify technical terminology, trade names of products and equipment occasionally will be used. No endorsement of products named is intended nor is criticism implied of products not mentioned.

2) Do not store the mixed material.

Cythion 95% (Malathion)*

1) Add 2.6 gallons of 95% cythion (4 oz/gal strength) or 3.2 gallons (5 oz/gal strength) or 3.9 gallons (6 oz/gal strength) to 100 gallons of fuel oil.†

†Strength to use dependent on local recommendations and situations.

Spraying and mist blowing—

Dibrom 8 (Naled)*

1) Add one gallon to 8 gallons of water.

2) Apply at a rate of one gallon per acre.

3) Rate should not exceed 0.1 pound actual naled per acre.

Fenthion (Baytex 4 lb.)*

1) Add one gallon to 40 gallons of water.

2) Apply at a rate of one gallon per acre.

3) Rate should not exceed 0.1 pound actual Fenthion per acre.

Cythion (Malathion 57%)*

1) Add 2 gallons to 98 gallons water.

Warning: All concentrations should be diluted accordingly, if application rate cannot be controlled at one gallon per acre. All directions and precautions appearing on the label of the insecticide container should be followed carefully.*

Dusting—Premixed dusts are available for use against adult mosquitoes. All directions and precautions should be followed. Dusts of the following insecticides are available: Carbaryl (Sevin), Dibron (Naled), Fenthion (Baytex).

Ground ULV †† application—Several machines are manufactured and sold commercially for this kind of application. Malathion, Dibron, Pyrethrins, Dursban and Resmethrin (synthetic pyrethrin) are registered for use in these machines. Each machine must be calibrated and used as directed by the manufacturer and the insecticide label.

Aerial application (conventional)—

Dibrom 14 (Naled)*

1) Add 2 to 4 quarts of Ortho additive to each 100 gallons of diesel oil to prevent the formation of sludge.

2) Add 50 to 100 ounces (1.6 to 3.1 quarts) to 100 gallons of diesel oil. (Equivalent to 0.05 to 0.1 pound actual.) Mix thoroughly.

3) Apply at a rate of one gallon per acre.

Cythion 59% (Malathion)*

1) Add 2.6 gallons to 97.4 gallons of diesel oil.

2) Apply at a rate of one gallon per acre.

Fenthion 9 pound/gal. (Baytex)*

1) Add 2 gallons to 98 gallons of diesel oil.

2) Apply at a rate of ½ gallon per acre.

Aerial application (ULV†† application)—

Dibron 14 (Naled)*

1) Apply at a rate of 0.5 to 1.0 fluid ounce per acre.

2) The 1.0-ounce rate is to be used in areas with heavy vegetation.

Cythion 95% (Malathion)*

1) Apply at a rate of 3 to 6 fluid ounces per acre.

2) The 6-ounce rate will provide some larval control.

††ULV (Ultra Low Volume) technique is the application of insecticide only, with no oils or other carrier being used. It requires special equipment. ULV sprays, with prolonged exposure, may spot some car finishes.

Chemical Control of Larvae

The chemical control of larvae (larvaciding) can be obtained by applying by ground or aerial equipment up to 10 quarts of formulation per acre* depending upon the concentration used. Oil or water emulsion formulation can be used in areas with minimum vegetative cover. Where vegetative cover is heavy, granular formulations should be used.

Organophosphorus compounds, such as Dursban and Fenthion, provide prolonged effectiveness in contaminated water at dosages five to ten times those listed. They can be applied to cover water surfaces in catch basins or at a rate of 15 to 20 gallons per acre* in open water courses. With a spreading agent at the rate of 0.5 percent, the volume can be reduced to two to three gallons per acre.*

The following insecticides will provide chemical control of larvae:

Insecticide	**Dosage (lb/acre)***
Abate	0.05-0.1
Altosid (Methoprene)	0.20-0.25
Dursban	0.0125-0.05
Fenthion	0.02-0.1
Malathion	0.20-0.5
Fuel oil	2 to 20 gal/acre

Warning: Fuel oils should not be used where vegetation or crops may be damaged. Abate and Dursban are not to be used in crop or pasture areas.

Chemical Control Around Homes

Mosquito control in individual yards or premises, especially where horses are kept, is important. Horse trailers, stalls and barns should be treated. Homeowners can provide some protection for themselves and their horses by spraying. Shrubbery and shaded areas should be treated. Sufficient water should be added to 57 percent Cythion (Malathion) to make the desired amount of spray:

—Five tablespoons plus water to equal one gallon of spray.*

—Thirteen ounces plus water to equal five gallons of spray.*

—Two gallons plus water to equal 100 gallons of spray.*

**NOTE: To convert to metrics, use the following equivalents: 1 quart = .95 liter; 1 gallon = 3.8 liters; 1 pound = .45 kilogram; 1 pint = .47 liter; 1 ounce = 30 milliliters; 1 acre = .4 hectare.*

CONTROLLING MOSQUITOES

AT HOME AND ON THE FARM

TO PROTECT HUMAN HEALTH, ECONOMY, AND RECREATION

MONTANA DEPARTMENT OF HEALTH AND ENVIRONMENTAL SCIENCES
ENVIRONMENTAL SCIENCES DIVISION
FOOD & CONSUMER SAFETY BUREAU
HELENA, MONTANA

AUGUST 1978

ADVERSE EFFECTS OF MOSQUITOES IN MONTANA

HUMAN HEALTH

Western equine and St. Louis encephalitis
(commonly called sleeping sickness)
Secondary infections
Shock reactions

ECONOMY

Medical costs
Repellent and chemical costs
Reduced weight gain in cattle
Reduced milk production
Reduced tourism
Reduced property values
Reduced labor efficiency
Reduced sales of recreational equipment

RECREATION

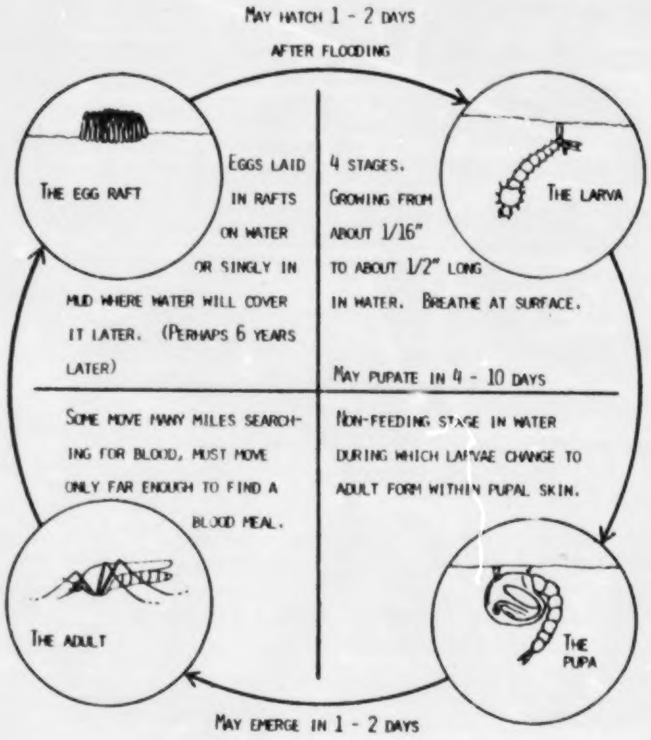
Fishing, camping, gardening, etc.

MOSQUITO LIFE CYCLE

A mosquito passes through the egg, 4 larval and the pupal stages before becoming an adult (Fig. 1). Development of the first three stages takes place in water. Since larvae (wigglers), pupae (tumblers) and some eggs will die if water is removed, the key to mosquito control is: FIND AND ELIMINATE MOSQUITO REARING SITES.

Not all water produces mosquitoes. Water which is open and deep, or has little shallow area, and that which is running and is relatively free of emergent vegetation does not. Temporary, shallow, standing water that lasts for 5 days during exceptionally hot weather can produce hordes of pest mosquitoes. More typically (at peak air temperatures of 80 - 90° F.) the egg to adult developmental time will be 7 or 8 days. The encephalitis bearing mosquitoes and related forms lay eggs on the surface of permanent or semi-permanent water which is typically shallow and has emergent vegetation. To establish if water does rear mosquitoes, dip out some water (near the surface and close to vegetation) at weekly intervals. Examine it for the aquatic stages sketched below.

Fig. 1 Life Cycle



Eggs laid in rafts on water or singly in mud where water will cover it later. (Perhaps 6 years later)

4 stages. Growing from about 1/16" to about 1/2" long in water. Breathe at surface.

Non-feeding stage in water during which larvae change to adult form within pupal skin.

Some move many miles searching for blood, must move only far enough to find a blood meal.

APPROACHING MOSQUITO CONTROL

While organized mosquito abatement districts can do more to control mosquitoes than an individual or small independent group, the property owner may be aple to do much to protect his health, recreation and economy. Persons living closest to a rearing site will have the greatest reduction of the number of mosquitoes in their area when mosquitoes are controlled at their source. Although some types of adult mosquitoes may commonly fly from 3 to 5 miles, they thin out as they disperse from a rearing site and most move only far enough to feed.

TO MINIMIZE ADULT MOSQUITO ATTACK

1 Minimize the amount of mosquito rearing water on your property according to the RULES following.
2. Keep lawns clipped short, weeds cut and bushes trimmed to reduce the cover provided to adult mosquitoes. They rest in these cool, shady, humid retreats during the day.
3. Keep window and door screens in good repair. A 16 x 16 mesh will keep out most types of mosquitoes but finer mesh may be needed for smaller types.
4. Repellents having a variety of active ingredients may be used for temporary relief. The U.S. Public Health Service and Consumer Reports state that the most effective mosquito repellent chemical is diethyl toluamide. Repellents with higher concentrations of this chemical are the most effective. Follow label directions and precautions.
5. Registered insecticides can be used for adult mosquito control. They can be applied to adult resting places as short term residual sprays, or space (contact) sprays can be drifted through areas on light air currents at dusk or dawn to kill adult mosquitoes present at that moment. Some aerosol bombs can be used to kill flying insects indoors. All insecticides must be used in accordance with label directions and restrictions.

RULES FOR REDUCTION OF MOSQUITO PRODUCTION

1. REMOVE UNNEEDED STANDING WATER ON YOUR PROPERTY. DISCARD TIRES, CANS, ETC., WHICH HOLD WATER. CLEAN RAIN GUTTERS. CLEAN BIRD BATHS WEEKLY. EXAMINE FLOWER VASES FOR EXCESS WATER.
2. STAGNANT POOLS OR SWAMPY PLACES SHOULD BE FILLED, DRAINED, OR DEEPENDED WHEN PRACTICAL. REMOVE DEBRIS AND FLOATING AND EMERGENT VEGETATION FROM NEEDED POOLS OR THOSE WHICH CANNOT BE FILLED OR DRAINED. AVOID HAVING SHALLOW POND MARGINS--STEEP STRAIGHT BANKS WITHOUT EMERGENT VEGETATION PROVIDE LITTLE COVER FOR MOSQUITO LARVAE.
3. ORNAMENTAL OR STOCK WATERING PONDS CAN BE STOCKED WITH FISH. TROUT OR OTHER GAME FISH KEEP PONDS FROM REARING MANY MOSQUITOES IF VEGETATION IS NOT TOO DENSE. MOSQUITOFISH AND GOLDFISH ARE EFFECTIVE.
4. SURFACE IRRIGATED FIELDS SHOULD BE PROPERLY GRADED. LOW AREAS IN FIELDS THAT POND WATER ARE MAJOR SOURCES OF MOSQUITO PRODUCTION. PONDING IS ALSO UNFAVORABLE FOR CROP GROWTH AND HARVESTING.
5. DO NOT OVER IRRIGATE FIELDS AND PASTURES. USING ONLY NECESSARY AMOUNTS OF WATER (WITH ADEQUATE FERTILIZATION) INCREASES HAY QUALITY AND YIELD AS WELL AS REDUCES MOSQUITO PRODUCTION.
6. DO NOT PERMIT FIELD LATERALS AND DRAINS TO CONTAIN EXCESSIVE AMOUNTS OF VEGETATION. THE ON-FIELD DITCHES SHOULD BE REGULARLY CLEANED AND MAINTAINED TO REDUCE MOSQUITO HABITAT.
7. REGISTERED INSECTICIDES CAN BE APPLIED TO MOSQUTIO REARING WATER ON YOUR PROPERTY IF APPLIED ACCORDING TO LABEL DIRECTIONS.

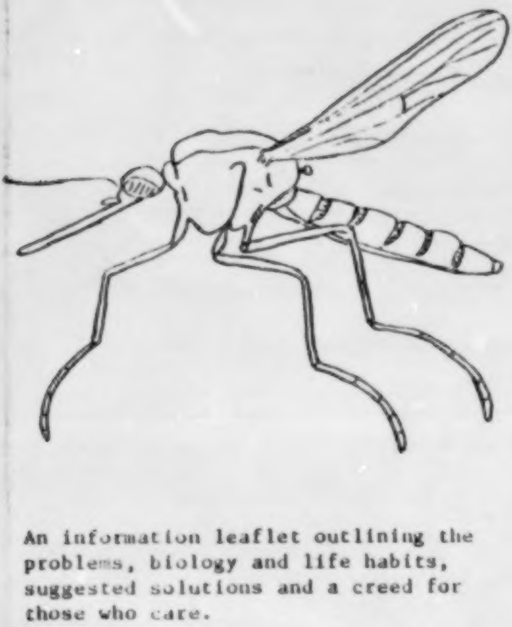
CONSULT YOUR LOCAL MOSQUITO CONTROL ORGANIZATION, LOCAL HEALTH DEPARTMENT OR THE MONTANA DEPARTMENT OF HEALTH AND ENVIRONMENTAL SCIENCES FOR FURTHER INFORMATION.

IF YOU HAVE A LOCAL MOSQUITO CONTROL DISTRICT, SUPPORT IT.

IF YOU DO NOT HAVE A MOSQUITO CONTROL DISTRICT, LOOK INTO FORMING ONE...THE STATE HAS ENABLING LEGISLATION.

THIS MATERIAL IS FURNISHED BY:

MOSQUITOES



An information leaflet outlining the problems, biology and life habits, suggested solutions and a creed for those who care.

This leaflet prepared by Elmer J. Kingsford, Logan City Mosquito Control Program, in cooperation with Reed S. Roberts, Entomologist, Cooperative Extension Service, Utah State University.

Graphics: Donald Jenny

COOPERATIVE EXTENSION SERVICE
UTAH STATE UNIVERSITY ● LOGAN

MOSQUITOES

Spread diseases to or otherwise cause unthriftiness in livestock.

Depress real estate values.

Prevent or discourage the use and enjoyment of recreational facilities.

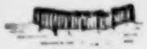
Spread diseases (encephalitis, malaria, etc.), cause allergic reactions, general discomfort and annoyance to man.

MOSQUITO FACTS

Only the female mosquito bites. The male feeds on nectar and plant juices.

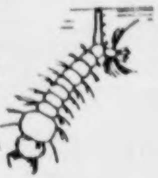
Adult flying mosquitoes do not develop in grass or shrubbery although they frequently rest there.

All mosquitoes must have water in which to pass their early life stages . . . Some mosquitoes lay their eggs on the water surface where they hatch in two or three days. Others lay their eggs in moist soil, old tires or other water holding containers, where they remain unhatched until covered by water.

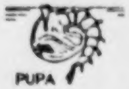


EGG RAFT

After hatching, the mosquito larva or wrigglers, grow rapidly turning into tumblers or pupae.

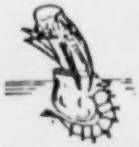


LARVA

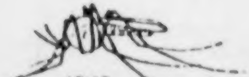


PUPA

The skin of the pupae soon splits open and out climbs another hungry mosquito.



ADULT EMERGING FROM PUPA



ADULT

MOSQUITOES CAN DEVELOP IN:

Ornamental ponds.

Swimming and wading pools.

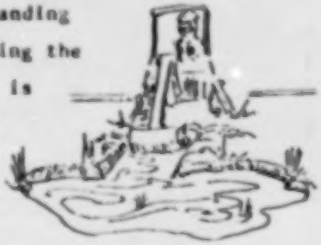
Containers of all kinds -- old tires, tin cans, buckets, animal watering troughs, etc.

Low spots or swales in fields, ditches, etc. where irrigation, seepage and other water stands.

MOSQUITO CONTROL

Mosquito Control encompasses three primary areas, environmental manipulation, exclusion and direct killing. Property owners and mosquito abatement districts share responsibilities in each area.

Environmental manipulation: Prevention of shallow standing water or otherwise altering the breeding site so that it is unfavorable for mosquito production. Property owners and organized mosquito abatement districts share responsibility in this area. However, the major responsibility belongs to the districts.



Exclusion: Screening or otherwise preventing mosquito access to buildings and homes. This area is the responsibility of the property owner. Mosquito abatement personnel may act as technical advisors.

Direct killing: Spraying or otherwise controlling mosquitoes. Mosquito abatement districts have primary responsibility in this area. Property owners are asked to cooperate by allowing access to breeding sources.

Additional information may be obtained from your local mosquito abatement district, health departme or agricultural extension office.

"I CARE"
MOSQUITO PREVENTION
PLEDGE

I/We agree to promote environmentally acceptable mosquito prevention and control by practicing and encouraging the practice of good water management techniques wherein irrigation waters are not applie in excess of crop needs or the soils absorptive capacity, ditches are maintained in good repair, relatively weed free, so that seepage and spills (where mosquitoes may breed) are prevented or kept at a minimum.

By practicing and encouraging the practice of good land management techniques wherein the surface topography is maintained or altered in a manner that does not lend itself to temporary or permanent shallow water collections in potholes, pools, ponds etc. (where mosquitoes may breed) but rather promotes adequate drainage or permanent deep water sites with abrupt, relatively weed free, shore line that prevent or discourage mosquito production.

The Utah Cooperative Extension Service, an equal opportunity employer, provides programs and services to all persons regardless of race, religion, sex, color or national origin.

Issued in furtherance of Cooperative Extension Work, Acts of May 8 and June 30, 1914, in cooperation with the U.S. Department of Agriculture. J. Clark Ballard, Vice President and Director, Extension Service, Utah State University.

Caution: ULV Malathion and Sevin may spot the finish of some cars. Remove them from spray area or place in garage during the spraying operation. Wash accidently exposed automobiles immediately with water plus detergents.

CONTROLLING MOSQUITOES INDOORS

Mosquitoes in the home can be killed using any good household spray that is sold for controlling flying insects indoors. Aerosol bombs containing Malathion, Methoxychlor, DDVP (Vapona), or Synergized Pyrethrins are all effective. Use these materials as directed on the label.

Another device which is very effective for use in homes, barns, poultry units, and other areas where mosquitoes are a problem is the DDVP (Vapona) slow release resin strip. Used as directed on the label, hanging one standard sized strip for each 1000 cubic feet of space. Observe all label precautions and use only according to label instructions.

REPELLANTS

For outdoor activity, repellants are probably the best protection against mosquito bites. Repellants will afford protection from 1 to 5 hours, depending on the amount of perspiration, skin rubbing, temperature, and abundance of mosquitoes. It is necessary to cover the skin areas to be protected evenly with repellant materials as mosquitoes are quick to find untreated areas. Some repellants sold for direct application to humans are Deet (diethyltoluamide), ethyl hexanediol, dimethyl phthalate, and dimethyl carbate. These materials may be purchased alone or in various mixtures. Applications can be made to clothing as well as exposed skin areas. However, they should not be used around the eyes, nose, or lips. Follow all label directions in their use.

Use of a trade name does not imply endorsement of one product over another.

FOLLOW ALL LABEL PRECAUTIONS WHEN USING INSECTICIDES. DO NOT APPLY INSECTICIDES OVER OR NEAR STREAMS OR PONDS WHERE FISH OR OTHER WILDLIFE MIGHT BE ENDANGERED.

Issued in furtherance of Cooperative Extension work, Acts of May 8 and June 30, 1914, in cooperation with the USDA. Hollis D. Hall, Director of Cooperative Extension Service, South Dakota State University, Brookings. Educational programs and materials offered without regard to age, race, color, religion, sex, handicap or national origin. An Equal Opportunity Employer. File: 9—[illegible]—71—[illegible] reprinted at estimated cost of [illegible] cents each—[illegible]—[illegible].

FS 444

MOSQUITO CONTROL

in and around homes and farmsteads

FS 444

Mosquito Control in and Around Homes and Farmsteads

By B. H. Kantack, Extension Entomologist, and
Wayne L. Berndt, Extension Pesticide Specialist

Mosquito control is necessary because of health, recreational, and economic reasons. This insect has plagued man for centuries, causing irritation and spreading disease among both man and animals. Encephalitis is one of the diseases mosquitoes spread. Annoyance by mosquitoes causes livestock to lose weight and reduces milk production. Although other types occur in South Dakota, the most abundant species are *Aedes vexans* and *Culex tarsalis*.

LIFE CYCLE AND BREEDING HABITS

Mosquitoes breed during the spring and summer months in the Northern plains. The primary prerequisite for their reproduction is water. This insect passes through four stages, three of which are in water: (1) the egg; (2) the larvae or wiggletail; (3) the pupa or tumbler; (4) the winged adult.

Female mosquitoes lay their eggs either on water, at the edge of water or, in other cases, on dry soil which has previously been flooded. The larvae which emerge from the eggs are strictly aquatic and cannot exist out of water. This stage usually lasts 10 days to 2 weeks depending on the temperature. The pupa or tumbler stage usually lasts about 3 days depending on existing temperatures. Length of the adult stage is variable, with some species hibernating through the winter. Life span of the adult is usually 4 to 6 weeks. Only female mosquitoes bite and take a blood meal. Male mosquitoes do not have mouthparts suited to piercing, hence they are not blood suckers. They feed on nectar and plant juices.

CONTROL – ELIMINATION OF BREEDING SITES

The first and most important control efforts should be directed toward elimination of potential breeding sites. Mosquito eggs cannot hatch nor can the larvae develop unless standing water is present. Where possible and practical:

- Remove all unnecessary, temporary water containers.
- Flatten or dispose of tin cans, glass jars, or other containers.
- Burn or remove old tires that may collect water.
- Place tight covers over cisterns, cesspools, septic tanks, fire barrels, rain barrels, and tubs where water is stored.
- Eliminate tree holes by filling with concrete.
- Empty and wash bird baths weekly.
- Check rain gutters for standing water.
- Remove water from flat roofs after rainfall.
- Drain or fill-in stagnant pools and swampy places. If pools or lagoons cannot be drained or filled, apply a suitable chemical treatment for mosquito larval control.
- Examine flower pots or planters around the premises for accumulated standing water where mosquitoes might breed.
- Check fish bowls and aquariums periodically for mosquito larvae.
- Check around animal watering troughs on the farmsteads for standing water.

OUTDOOR CONTROL OF ADULT MOSQUITOES

In addition to the elimination of breeding sites, adult mosquito control may also be necessary to keep mosquito populations below irritating levels. Even though all breeding sites are eliminated in an area, some adults will migrate in from adjacent areas. Where adult control is desired around the home, keep all weeds and grass cut and apply a residual spray.

Residual Sprays Recommended for Adult Mosquito Control Outside Homes

Insecticide	Formulation
Malathion (Premium Grade)	2% spray — dilute 50-57% emulsifiable concentrate 1 part to 28 parts of water or 4% dust — apply to gardens, lawns, flower beds, and shrubs
Carbaryl (Sevin)	1 lb. actual (1.25 lbs. 80%) wettable powder in 100 gallons water or 2 tablespoons of 80% wettable powder in 1 gallon of water

Thoroughly spray to the point of run-off lower limbs of shade trees, shrubbery, flower beds, grass, and shaded areas around buildings where mosquitoes congregate. For best results spray in the evening when mosquitoes are active, usually from 15 minutes before sunset to 1¼ hours after sunset. Repeat application every 7-14 days as needed.

Note: Sevin insecticide sprays may injure Boston ivy and should not be used on this ornamental plant. Follow all label directions when using these insecticides.

For control around farmsteads, parks, golf courses, and picnic grounds, aerial sprays of ULV* Malathion at 6 to 8 ounces or ULV Naled (Dibrom) at 1 ounce actual per acre or Sevin applied by air at three-fourth pound active per acre as a conventional spray are very effective. Apply directly over the farmstead and adjacent land to cover a 25- to 40-acre area.

Dairy cattle cannot be sprayed directly with Malathion or Sevin and should be confined to the barn during the actual spray operation. They may be turned out on the treated areas immediately after spraying.

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*Ultra low volume.

WHAT YOU CAN DO

THE INDIVIDUAL RESIDENT CAN DO MORE TO CONTROL MOSQUITOES AROUND HIS OWN HOME THAN ALL OTHER METHODS COMBINED.

PROPER MAINTENANCE of your property is the first step. All trash and refuse that could contain water should be eliminated. Gutters should be cleaned to ensure proper drainage. The property should be adequately graded and drained, to prevent any accumulation of stagnant water. Weeds should be kept under control.

CHEMICAL CONTROL of mosquitoes is safer and more effective when done by an individual, rather than by the the community. A fog or mist with a Pyrethan base should be used for quick killing action. A water-soluble malathion or sevin spray is also recommended for spraying around shrubs and flowers, under eves, and along fences and other areas where mosquitoes tend to roost. This should be done on a weekly basis during periods of high infestation. Be sure to follow the directions on the label for any insecticide used.

AFTER YOU HAVE done all you can to keep down the number of mosquitoes on your property, you can protect yourself against the ones that remain by being sure your home is adequately screened, by wearing protective clothing, and by using mosquito repellent, which is quite effective.

DO YOUR PART

HELP KEEP THE MOSQUITOES OUT OF OUR COMMUNITIES THIS SUMMER!

TRI-COUNTY DISTRICT HEALTH DEPARTMENT

ADAMS CITY OFFICE
4301 East 72nd Avenue
Adams City, 80022
288-6816

AURORA OFFICE
Altura Plaza, Suite 309
15400 East 14th Place
Aurora, 80011
341-9370

BRIGHTON OFFICE
1895 Egbert
Brighton, 80601
659-8333

CASTLE ROCK OFFICE
502 Third, P. O. Box 670
Castle Rock, 80104
688-5145

ENGLEWOOD OFFICE
4857 South Broadway
Englewood, 80110
761-1340

SHERIDAN OFFICE
3265 West Girard
Englewood, 80110
761-0383

WEST ADAMS OFFICE
Turnpike Towers, Suite 401
7475 Dakin Street
Denver, 80221
428-8543

We Need YOUR Help

to Control Mosquitoes

THE MOSQUITO PROBLEM

EVERYONE KNOWS only too well how much discomfort a mosquito bite can cause. This irritation is produced by a small amount of liquid that the mosquito injects under the skin when it bites.

ONLY FEMALE mosquitoes bite humans and animals. Males live on plant juices, which are also eaten by females when blood is not available.

MOSQUITOES HAVE long been known as carriers of diseases, such as malaria, yellow fever, and encephalitis. Outbreaks of mosquito-borne encephalitis have been known to occur in Colorado. Although the number of mosquitoes has not decreased significantly, much progress has been made in controlling the diseases they carry, through increased knowledge and effective control of certain species.

HOW MOSQUITOES MULTIPLY

FOUR SPECIES of mosquitoes exist in this area of Colorado: *Aedes dorsalis*, *Aedes nigromaculis*, *Aedes vexans*, and *Culex tarsalis*. All of them begin life as an egg, which can often survive drying and cold, and which may lay dormant for more than a year.

UNDER PROPER conditions, the egg hatches in two or three days into a larva, which is aquatic, but must breathe air. The larval stage lasts from four to ten days, after which the larva pupates and hatches in a very short time into a winged adult.

MOSQUITOES CAN breed in very small areas of water, including tin cans, old tires, drain troughs, etc. Large and deep bodies of water are usually *not* good mosquito-breeding areas, because of the action of fish and waves. Mosquito larvae cannot survive without still water or protection from vegetation.

HOW MOSQUITOES ARE CONTROLLED

THE MOST EFFECTIVE means of controlling mosquitoes is the elimination of breeding areas through drainage. If this is impossible, oil can be applied to the surface of small, stagnant ponds, provided there is no danger of water pollution. The oil blocks the air breathing tubes of the larvae, which will die if they cannot get air. Chemical larvicides, such as Baytex, are also available, but they must be used with caution, since they could have an effect on other wildlife.

FISH THAT FEED on mosquito larvae, such as Gambusia affins ("pot bellied minows"), are sometimes used in mosquito control. Other natural enemies of mosquito larvae include some aquatic insects, such as dragon fly larvae.

CONTROLLING ADULT mosquitoes is much more difficult than controlling the larvae, because they cover a much larger area and are not water-bound. Fogging and spraying have been used in large areas, but they are only *20% effective* under ideal conditions, which seldom exist. This method is undesirable in any case, because the insecticide could have harmful effects on humans or other animals.

ADULT MOSQUITOES have several natural enemies, including birds, bats, and dragon flies.

Project II-D.2 Estimating the Amount and Sources of Funding

Make an area resource survey in one or both of the following ways to determine the amount of money, volunteer time, equipment on short term loan and just plain good will is available:

1. Include items on a Survey of Residents and Businesses (including farm operations) (Project II-A.3).
2. Use the telephone book and local directories to locate and estimate resources available from:
    - a. City, County, State and Federal Agencies in the area
    - b. Water and drainage districts
    - c. Civic service clubs
    - d. Farm and Business associations
    - e. Educational and Youth Clubs
    - f. Volunteer organizations
    - g. Planning associations
    - h. Medical and Veterinary associations
    - i. Recreational and Sporting Clubs
    - j. Agricultural chemical applicators (air and ground)
    - k. Pest control operators
    - l. Educational institution faculty and students
    - m. Public relations firms: newspaper, radio, TV, billboard
    - n. Other individuals or groups who may have an interest in mosquitoes or have equipment useable for mosquito management such as heavy equipment schools and Reserve Units.
3. Prepare a report for your study area on one or more of the following:
    - a. The possible annual rate of funding for mosquito management
    - b. Organizations interested in mosquito control
    - c. Support from an interested person, group or firm
    - d. Persons interested in participating in mosquito management
    - e. Equipment available for difficult and large area control operations including cleaning up water holding trash.

Projects completed:

		(Signed)
project or report title	date	manager, teacher, leader, parent

Project II-D.3 Designing a Control or Management Program (Figure 10)

1. Select the type of program appropriate for the severity of the pest problem (Project II-A.3):
   - a. Public education leaflets
   - b. Plus community assistance for private control operations
   - c. Plus community response to private request for control
   - d. Plus public agency program with private assistance
   - e. Plus fully funded public agency program

2. Select the location of program management and records center:
   - a. Volunteer coordinator (Figure 11)
   - b. Part-time position for community resident
   - c. City or county employee or official
   - d. Organized mosquito district manager

3. Determine the duration of active program management:
   - a. Mosquito season
   - b. Summer job
   - c. School year
   - d. Full year

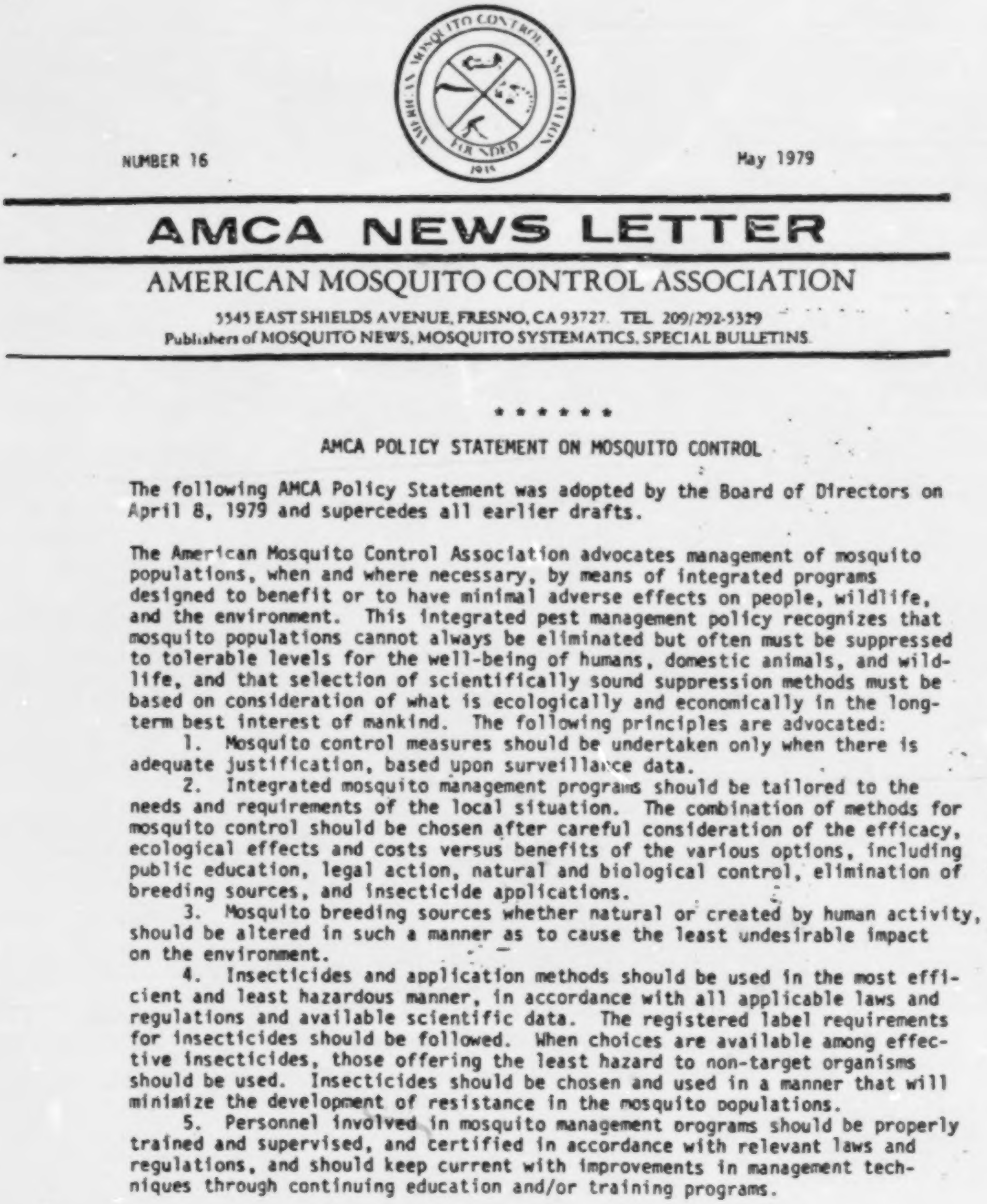
4. Determine the main types of breeding sites and pest species that will influence the program control options:

	Breeding Site Types	Pest Species	Generations/Year
a.	Spring flooding	Aedes	one to several
b.	Swamps and marshes		
c.	Flooding type irrigation		
d.	City sewers and drains		
e.	Tree holes		
f.	Junk and containers		
g.			
h.			

5. Prepare a report on your study area relating what is known of the above 4 factors to the resources available for your house lot, city block, farm, community, city, or county.

Projects completed:

		(Signed)
project or report title	date	manager, teacher, leader, parent



NUMBER 16 May 1979

AMCA NEWS LETTER

AMERICAN MOSQUITO CONTROL ASSOCIATION

5545 EAST SHIELDS AVENUE, FRESNO, CA 93727. TEL 209/292-5329
Publishers of MOSQUITO NEWS, MOSQUITO SYSTEMATICS, SPECIAL BULLETINS

* * * * * *

AMCA POLICY STATEMENT ON MOSQUITO CONTROL

The following AMCA Policy Statement was adopted by the Board of Directors on April 8, 1979 and supercedes all earlier drafts.

The American Mosquito Control Association advocates management of mosquito populations, when and where necessary, by means of integrated programs designed to benefit or to have minimal adverse effects on people, wildlife, and the environment. This integrated pest management policy recognizes that mosquito populations cannot always be eliminated but often must be suppressed to tolerable levels for the well-being of humans, domestic animals, and wildlife, and that selection of scientifically sound suppression methods must be based on consideration of what is ecologically and economically in the long-term best interest of mankind. The following principles are advocated:

1. Mosquito control measures should be undertaken only when there is adequate justification, based upon surveillance data.
2. Integrated mosquito management programs should be tailored to the needs and requirements of the local situation. The combination of methods for mosquito control should be chosen after careful consideration of the efficacy, ecological effects and costs versus benefits of the various options, including public education, legal action, natural and biological control, elimination of breeding sources, and insecticide applications.
3. Mosquito breeding sources whether natural or created by human activity, should be altered in such a manner as to cause the least undesirable impact on the environment.
4. Insecticides and application methods should be used in the most efficient and least hazardous manner, in accordance with all applicable laws and regulations and available scientific data. The registered label requirements for insecticides should be followed. When choices are available among effective insecticides, those offering the least hazard to non-target organisms should be used. Insecticides should be chosen and used in a manner that will minimize the development of resistance in the mosquito populations.
5. Personnel involved in mosquito management programs should be properly trained and supervised, and certified in accordance with relevant laws and regulations, and should keep current with improvements in management techniques through continuing education and/or training programs.

Figure 10. AMCA Policy Statement on Mosquito Control

CHECK LIST FOR A COOPERATIVE COMMUNITY MOSQUITO REDUCTION PROGRAM

I. Mapping

  A. Large area program map (on one sheet) with sufficient detail to draw in the boundaries of:

    1. Protected area - that area in which a minimal mosquito population is desired.

    2. Barrier zone - that area around the protected area (about 1 mile across) in which control operations are carried out in normal years.

    3. Outlying area - major breeding areas beyond the barrier zone and areas that are in neighboring control programs.

  B. Small area control maps (one sheet per ¼ section, 8 inches to the half mile) on which to plot survey results and control operations.

II. Adult Survey

  A. Landing rates, biting collections, and light trapping.

  B. Determine:
    1. Density and species of pest populations
    2. Community tolerance threshold
    3. Effectiveness of control operations
    4. Breeding areas

III. Larval Survey (number of wigglers per dipper of water)

  A. Identify actual breeding sites and plot on small area control maps.

  B. Classify breeding sites for type of control and priority of control.

IV. Control Program Management

  A. Coordinator of volunteers, maps, and records

  B. Liaison with a state or regional mosquito authority.

  C. Individual owners responsible for small breeding sites

  D. Large breeding areas require:

    1. Cost estimates for possible control options;

      a. water management
      b. drain, fill, or deepen
      c. mosquito fish
      d. larviciding
      e. adulticiding

    2. Cost sharing of control with owners.

    3. City, county or contracted program operation.

Figure 11. A Community Mosquito Reduction Program Check List

Project II-D.3a News Bulletins and Group Project Status Reports

Whenever more than a few people are involved in an enterprise the need for coordinating their efforts and for maintaining a history of accomplishments requires records, current, accurate records including weekly, seasonal and annual summaries. Distribution is by newspaper, radio, TV, mail and bulletin board. Items and regular departments in mosquito management bulletins and reports are:

a. Larval survey results

b. Adult mosquito survey results

c. Control suggestions for residents, farms, and businesses

d. Weather and water conditions

e. Mosquito outlook for the next week

f. Volunteer duty assignments and coordination meetings

g. Organizational news

h. Management decision meetings on specific sites in which at least one person is present for each type of interest in the site.

i. Changes in boundaries of control areas

j. Equipment needs for specific projects

k. Contributions of time, equipment, space, supplies and funds

l. Breeding reduction projects by individuals, farms, and businesses

m. Comments by agencies: Extension Service, County Health Officer, State Entomologist, State Health Office

An 8½ by 11 inch sheet folded in half produces a four page bulletin. The 5½ by 8½ inch pages are a nice size for short articles and notices. The two center pages can also be used for a map.

Projects completed:

1. Wrote a news item on local mosquitoes ______ (Signed) ____________________

2. Arranged with local media for distribution of mosquito reports ______ ____________________

3. Designed a news bulletin ______ ____________________

4. Set up a records center for mosquito control ______ ____________________

5. ____________________ ______ ____________________

6. ____________________ ______ ____________________

project or report title   date   manager, teacher, leader, parent

Project II-D.4 Estimating Costs for Large Area Control Options

After a community clean up of daytime mosquito hiding places and of water containing junk and other small area breeding sites, what remains are the large or difficult breeding sites. Typically there are a number of ways to reduce or prevent breeding for each site. There is no one best option for all sites. The best option for a particular site is the one that is effective, is politically and environmentally possible and for which equipment and funds are available or can be arranged.

Mosquito larae require calm, protected, shallow, fish-free water. Flood water mosquito eggs require flooding to hatch. Female mosquitoes require daytime hiding places and blood to produce eggs. Remove any of these factors eliminates mosquitoes. For each site consider the costs of possible options including the following:

1. Water management
    a. Overflood ponds early in the year and hold the level steady or receding thereafter to prevent egg hatch.
    b. Hold irrigation water on fields for a time less than that needed for larval development to be completed.
    c. Maintain ditches and drains to prevent breeding in vegetation along the sides, in the bottom when the flow is cut off, or in soggy areas due to leaks in the system.
2. Drain, fill or deepen
    a. An entire site may be drained (or prevent water from entering) or filled or deepened, to support fish, with clean banks.
    b. A site may be deepened in one part. The soil removed is used as fill in another part. The deepened part serves as a drain for the remainder. This method improves wildlife production by providing a greater variety of habitats in the area.
    c. An alternate use of the site may be possible which will perform the above in the process of development (asphalt and Sak-rete!).
3. Mosquito predators
    a. Improve the site so native fish can survive.
    b. Stock with mosquito fish, *Gambusia affinis*. If this fish will not overwinter, the cost of restocking must be considered.
4. Larviciding with weekly larval counts
    a. Individual site treatment by hand or ground equipment
    b. Large area treatment by ground or aerial equipment
5. Adulticiding with quality control counts or collections
    a. As an emergency treatment for severe biting or vector mosquitoes
    b. As a prescription treatment for special outdoor events

Projects: 1. Report on best options for a selected site.
2. Cost and availability of an option in your community.
3. Raise *Gambusia affinis*, release in spring, and monitor.

Project #____ completed ______ (Signed)____________________________
date manager, teacher, leader, parent

Project II-D.5 Cost Sharing of Breeding Site Reduction with Landowner

Landowners have an obligation to the public to not let their property become a nuisance or a source of nuisance. The public has an obligation to itself to adopt those methods of mosquito control that are environmentally sound and that will in the long run be the least costly. Such methods normally cost a great deal more the first years than annual short term options and much less thereafter. When it is in the best interest of the entire community, including the owner, to carry out an expensive permanent control operation, cost sharing is a possible solution for paying the bills.

1. Select a site where water management, drain-fill-or-deepen, or fish are considered appropriate methods of reducing breeding (P. II-D.4).
2. Find who owns the site and the land around it that may be affected by environmental modifications carried out on the breeding site.
3. Prepare a map of all possible affected areas. Ownership maps are available at some banks, title companies, real estate offices and county court house recorder's offices.
4. Determine who all have an interest in the land: owners, renters, city, county, highway, railroad, potential developers, wild life commissions, parks service, Corp of Engineers and other agencies. (The more the better, see #6 below.)
5. Develop a preliminary budget for specific work needed to correct the breeding site such as:
    a. cost of installing a new water control gate
    b. cost per foot of drainage ditch
    c. cost per hour for deepening and hours estimated to do the job
6. Determine the benefits of the operation to each interested party and all persons living within mosquito flight range (¼ to 1-5 miles).
7. Assign the cost in the same ratio as the benefits.
8. Determine the ability of each party to pay the above cost.
9. Reassign the cost on a most reasonable basis as of this date.
10. Discuss the plan with each type of interest individually followed by a joint meeting if indicated.
11. Review steps 2 - 10 annually until the source is controlled.

For a large area, each of the above steps is a significant project if the records are maintained by a responsible person or office. For smaller areas, more than one step should be grouped for a project.

Projects or steps completed:

		(Signed)
project or report title	date	manager, teacher, leader, parent

Project II-D.6 Forming an Organized Control District

The main function of a control district manager used to be the coordination of control operations and of district employees. Now it is to negotiate large area breeding site reduction with landowners, public relations, and public education for the control of small breeding sites. Coordination now includes the control operations of individuals, farms, business firms, and community-spirited volunteers. This is a 12 month a year job treating causes rather than symptoms. Many of the same activities are involved in organizing and in maintaining a district if the district management evolves from within the community.

1. Select an interim program coordinator (II-D.3)

2. Obtain basic information by all or most of the following projects:
    a. Control district area (II-A.1)
    b. Human attitudes toward the pest population (II-A.3)
    c. Species of pest mosquitoes (II-B.2)
    d. The size and duration of the pest population (II-B.3)
    e. The relative size and location of breeding sites to the protected area (II-C.2)
    f. Estimate of community resources (II-D.2)
    g. The advice of available authorities (I-A, B, C, and D)

3. Develop a leaflet on the need for an organized district based on more than one of the above information projects (II-D.1).

4. Prepare a speach on the advantages of an organized district based on American Mosquito Control Association Bulletin #4 (I-D).

5. Hire a professionally trained manager full time or share with another district or duties.

6. Maximize the stability and long term control options by giving the program an independent tax base as an organized district incorporated under state law in states where enabling legislation has been passed.

Each step is a project in itself and often can be subdivided to match local conditions. The sequence is only a suggestion.

Projects completed:

		(Signed)
project or report title	date	manager, teacher, leader, parent

Project II-D.7 Calibrating Pesticide Application and Equipment

Errors in application result both in failure of expected control and in hazards to health and the environment. Major sources of error are poor calibration of equipment and failure to maintain calibration.

Calibration involves two steps:

1. Determining how much material is delivered per unit area (gallons or pounds per acre or square foot). At times this is converted into a unit of time (oz/min) or of distance (oz/mile).
2. Calculating the amount of product to add to the spray tank to obtain the desired rate of application of active ingredient by following the label directions. (Granules used for larviciding are ready to use as purchased so no calculation is needed.)

Activities in which calibration is important are:

1. The rate of travel (Project II-D.7a)
2. Estimating the size of an area to be treated (II-D.7b)
3. The rate of application by area, time, or distance (II-D.7c)
4. Simulation of practical application problems (II-D.7d)
   a. uniform droplet size
   b. uniform distribution of droplets and granules
   c. uniform pattern and swath overlap
5. Supervision of contracted application (II-D.7e)
6. Detecting inversion conditions (II-D.7f)

A record of the total amount of material used divided by the total area treated yields the average rate of application and indicates if calibration was maintained. It does not provide an indication of the uniformity of the application. A control failure can occur from the non-uniform application of the required dosage. Surviving mosquitoes are an indication of the problem but not a confirmation.

To determine the uniformity of a treatment, the conclusion must be based on more than one sample. The treatment must be divided into several sections or areas from which multiple samples are taken.

The calibration process can be repeated several times or the records of a number of applications averaged to estimate the true rate of application. This is the normal procedure for control operations. The practice has serious limitations with new control materials that must be applied uniformily for proper results (Rathburn et al 1979).

Serious calibration requires the use of simple statistics and multiple sampling techniques. Then not only the average but also an estimate of the reliability or uniformity of results can be given with a desired assurance of confidence (or lack of confidence). The following projects are for both practical training and an easy means of generating data for practice in using simple statistics (Part III-A).

Reference:

Rathburn, Jr., C. B., E. J. Beidler, Glennon Dodd and Albert Rafferty. 1979. Aerial applications of a sand formulation of Methoprene for the control of salt-marsh mosquito larvae. Mosquito News 39(1): 76-80.

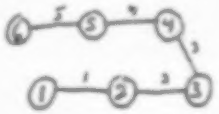
Project II-D.7a Calibrating the Rate of Travel

Both the average rate of travel and the uniformity of the rate of travel can be obtained by using a measured course for walking (running, bicycling) or driving at 5 to 15 miles per hour.

1. Average rate: (as most applicators calibrate the rate of travel)
   a. Measure the distance between two reference points at least 30 seconds apart.
   b. Record the times to travel the distance both ways with applicator.
   c. Average the two times (feet/second or minute or meters/sec or min).

- - - - See Part III before doing the following project - - - - - - - - - - -

2. Uniformity of rate: (and as a result, uniformity of application rate)
   a. Measure the distance between two reference points as above, or better, measure equal distances between reference points set out on a course with 4 or more legs over typical terrain.



   b. Record the times needed to travel each leg of the course.

   105, 108, 99, 103, 110 seconds $\bar{x} = \frac{\Sigma x}{n} = \frac{525}{5} = 105$ sec/leg

   c. Calculate the Standard Deviation (Project III-A.3a).

   $SS = \Sigma x^2 - \frac{(\Sigma x)^2}{n} = 74$ $SD = \sqrt{\frac{SS}{n-1}} = \sqrt{\frac{74}{4}} = \pm 4.3$ sec

   d. About 68% of the time the rate of travel (application rate) for a leg of the course is expected to fall within the range of ± 1 SD which is within __4__% of the mean.*

   $CV = \frac{100 \times SD}{\bar{x}} = \frac{100 \times 4.3}{105} = 4.1\%$

   e. Calculate the Standard Error of the mean (average) and the 95% Confidence Limits (Project III-A.3b).

   $SE = \frac{SD}{\sqrt{n}} = \frac{4.3}{\sqrt{5}} = \pm 1.9$ sec $CL = \bar{x} \pm t \times SE = 105 \pm 5.3$ sec
   $(105 \pm 2.6 \times 1.9)$

   f. About 95% of the time the average rate of travel (application rate) for the course is expected to fall within __5__% of the mean.*

   $\frac{100 \times 5.3}{105} = 5.1\%$

   g. Verify the above calculations.

*Assuming a uniform rate of product discharge and distribution from applicator.

Compare the performance of different persons or of the same person at different times (days) on the course using the research designs in Part III.

Project	Example Conditions	Replace With
III-A.4b	Sites and counts	Person and times for each leg
III-A.4c	Sites and time blocks	Person and legs
III-A.4d	Sites, time block and person	Person, leg and leg sequence
III-A.4e	Site, year, and week	Person, day, and leg

Projects completed:

		(Signed)
report title	date	manager, teacher, leader, parent

Project II-D.7b Estimating the Size of the Area Treated

Application is generally made to irregular areas and often only to portions of an area that can be measured on aerial photos or maps. Such areas must be estimated by the applicator or the applicator must learn to use a uniform rate of application. A common means of estimating the size of an area is to step it off prior to or during the application. The amount of material used divided by the area will yield the average application rate.

1. Length of step: (as is generally done)
   a. Step off twenty steps of the length used in field work.
   b. Measure the distance traveled.
   c. Divide the distance traveled by the number of steps.
   d. Express results as ft/step or m/step and as steps/100 ft.

- - - - - - - See Part III before doing the following project - - - - - - - -

2. Uniformity of step: (and as a result, uniformity of application rate)
   a. Set out a course as in project II-D.7a.
   b. Measure the distance traveled on each leg with 20 steps.

   52, 54, 50, 51, 55 ft $\bar{x} = \frac{\Sigma x}{n} = \frac{262}{5} = 52.4$ ft/20 steps (2.6 ft/step) (38.5 steps/100 ft)

   c. Calculate the Standard Deviation (Project III-A.3a).

   $SS = \Sigma x^2 - \frac{(\Sigma x)^2}{n} = 17$ $SD = \sqrt{\frac{SS}{n-1}} = \sqrt{\frac{17}{4}} = \pm 2.06$ ft

   d. About 68% of the time the length covered (application rate) on a leg of the course is expected to fall within the range of ± 1 SD which is within __4__% of the mean.*

   $CV = \frac{100 \times 2.06}{52.4} = 3.96\%$

   e. Calculate the Standard Error of the mean (average) and the 95% Confidence Limits (Project III-A.3b).

   $SE = \frac{SD}{\sqrt{n}} = \frac{2.06}{\sqrt{5}} = 0.92$ ft $CL = \bar{x} \pm t \times SE = 52.4 \pm 2.6$ ft
   $(52.4 \pm 2.8 \times 0.92)$

   f. About 95% of the time the average length covered (application rate) on the course is expected to fall within __5__% of the mean.*

   g. Verify the above calculations. $\frac{100 \times 2.6}{52.4} = 4.9\%$

* Assuming as in project II-D.7a and that the width of swath is uniform. Under actual working conditions even greater variation can be expected than in the examples in projects 7a, b, and c. This can be confirmed by calibrating under actual field conditions. One person times and records as the other makes the applications. Periodically the amount of product used (or collected in containers) is measured or weighed and recorded. Were 49 (Project II-D.7c) the correct application rate, the dosage range would be from 31% to 204% or a 7 fold range using granules (or rice).

Projects completed: (Also compare performances as in project II-D.7a)

____________________ ______ (Signed)____________________

____________________ ______ ____________________

report title date manager, teacher, leader, parent

Project II-D.7c Calibrating Application Rate by Area, Time and Distance

Where the area can be accurately measured, the amount of material used divided by the area yields the rate of application. The rate of application is often easier to use when based on time or distance, rather than on area, for irregular breeding sites for both ground and aerial work.

1. Application rate of granules: (as is generally done)
   - a. Apply granules over measured course at a uniform rate of travel.
   - b. Record the amount used and the time required.
   - c. Divide the amount used by the area for lb/acre.
   - d. Divide the amount used by the time for lb/min or oz/min.*
   - e. Divide the amount used by the length of the course for oz/mile.*
   - * For the swath width, rate of travel, and application rate in step c.

- - - - - - - See Part III before doing the following project - - - - - - - -

2. Uniformity of application rate of granular larvicides:
   - a. Put out one (or more sets) of identical containers in the treatment area spaced 1/10 the width of the swath including two beyond the swath limits. Sample four or more applications.

Container lay out (II-D.7d, #3)

, 7 , 6	5 , 4 , 3 , 2 , 1 , 1 , 2 , 3 , 4 , 5	6 , 7 ,
lap	swath width	lap

   - b. Record the times required, the total amount of material used and the amount in each container per application.
   - c. Divide the total surface area of a set of containers by the total weight of granules they collected in a treatment for the average container rate (lb/acre). A comparison with the total amount applied to the area (lb/acre) indicates the efficiency of the containers to sample the granules.
   - d. Determine the uniformity of application within the treatment area using the proper research design (Project III-A.4e).

Ounces or grams of granules per container

Replication or Duplication	Distance from path of applicator (spaced 1/10 of swath)										
	Left side					Right side					
	5&6	4&7	3	2	1	1	2	3	4&7	5&6	mean
1	32	27	37	42	36	50	48	35	36	35	38
2	74	24	49	76	50	21	23	56	43	56	47
3	49	38	84	71	38	50	40	34	41	52	50
4	15	30	88	100	24	82	86	70	43	56	59
5	93	99	48	52	46	16	64	22	27	48	52
Sample means*	53	44	61	68	39	44	52	43	38	49	49

* Sample means 95% Confidence Limits = ± 19.6 or 40% of the grand mean (49). The random variation in the application was so great there are no significant differences between any of the means! Were the weights mortality rates, the range of kill would be from 15% to 100% with the average a failure.

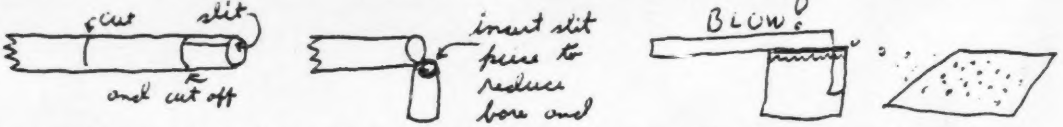
Projects completed: (Verify the ANOVA table or do a calibration)

		(Signed)
project or report title	date	manager, teacher, leader, parent

Project II-D.7d Simulating Practical Application Problems

Three factors still challenge applicator's attempts at uniform control:

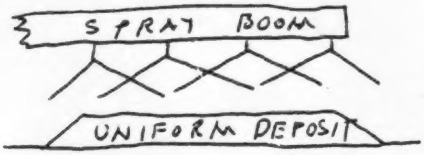
1. Uniform droplet size: Droplets are typically produced by injecting a liquid into a stream of rapidly moving air. You can use a hand spray gun loaded with water and food coloring or make your own sprayer from a straw.

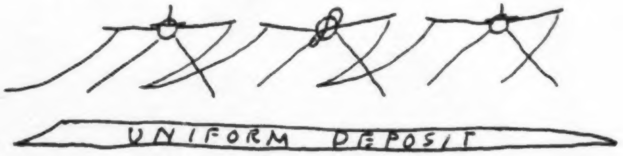


Use good quality white paper for the target area. Measure the largest spot and the smallest. Subtract, and divide the range into 5, or more odd-numbered classes of size. Count the number of drops in each size class, plot on a chart, and determine the percent of drops in each size class. Cube the mean diameter of each class and multiply by the number of drops in the class to obtain the relative volume. Again determine the percent of volume in each class. How many small droplets could be made from the largest droplet?

2. Uniform distribution of droplets and granules: Because the droplets are of different sizes they sort out as they fall. Use a grid over your droplet patterns and count the total number of droplets per unit area. Also compare the distribution of droplets by their size class (Figure 12).

3. Uniform pattern and swath overlap: The nozzels on spray booms are set for an overlapping pattern. The overlap then produces an even distribution below the boom. The same idea is used by aircraft with each swath overlapping the next. By working an area across the wind, the drift from one swath to the next helps insure uniform coverage. Flying across the wind also permits a uniform ground speed.





The problems of distribution and pattern overlap are present in calibration project II-D.7c. By adding the particles in container 6 to 5 and those in 7 to 4, the effects of overlap are simulated. Rice and $8\frac{1}{2}$ by 11 inch sheets of paper can be used indoors to simulate the distribution of granules or droplets. The collected rice can either be weighed or just counted and each kernel given an arbitrary weight such as 1 gram.

Use water in a clean boom sprayer and calibrate each nozzle using the research design in project II-D.7c (replace container with nozzle). Collect 5 one-minute samples from each nozzle.

Projects completed:

		(Signed)
project or report title	date	manager, teacher, leader, parent

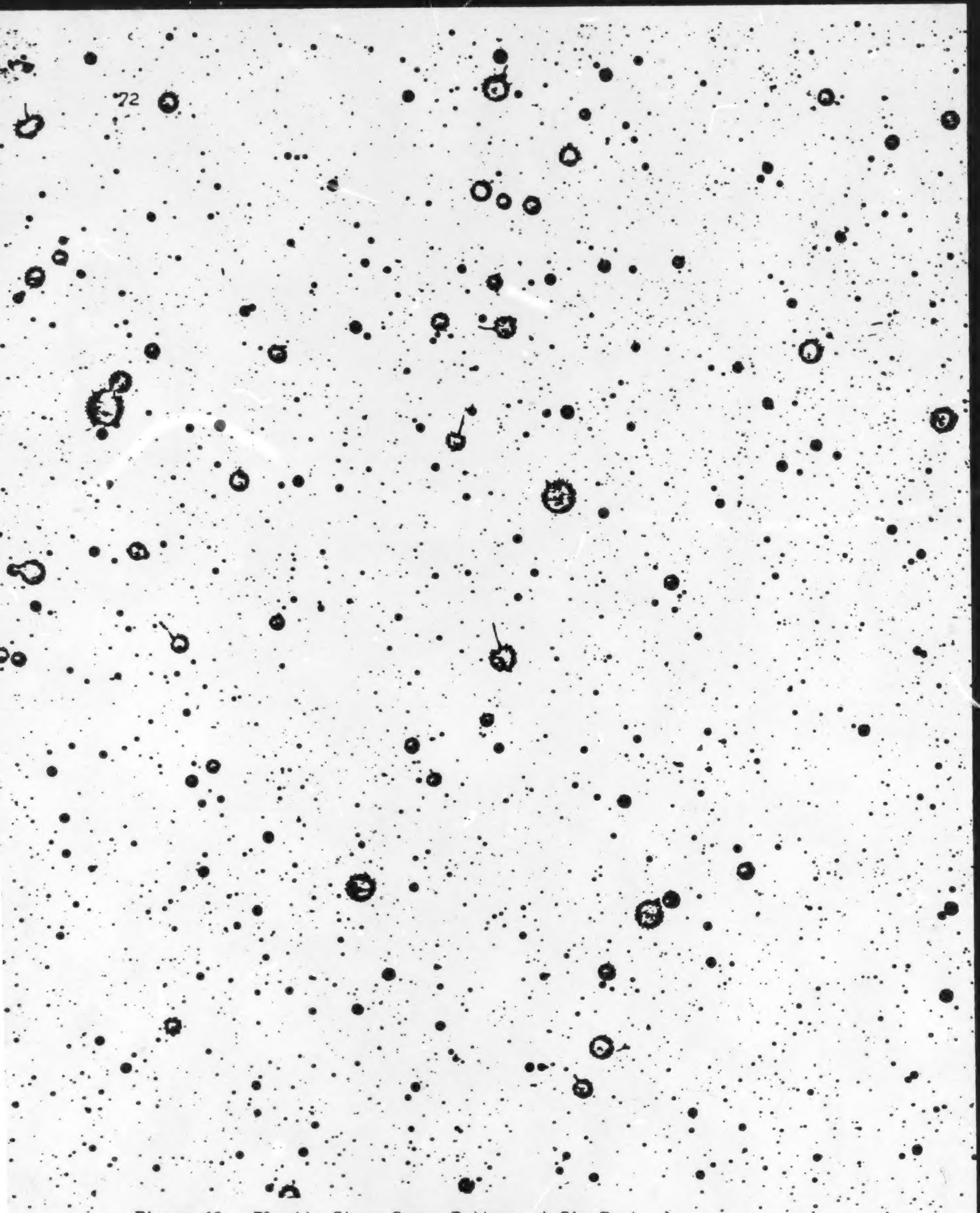


Figure 12. Plastic Straw Spray Pattern at Six Feet

Project II-D.7e Supervision of Contracted Application

Three areas of quality control exist when using contracted services:

1. Preparation of the contract:
    a. Liability defined and insured.
    b. Performance defined and related to payment, such as:

Percent rate of kill:	50	60	70	80	90	100
Percent payment:		0*	25*	50*	75	100

* or reapplication as needed before full payment

2. Application: Amount of product reported applied to a given area related to:
    a. Invoices or actual monitoring of loading.
    b. Flagging (path) and timing of aerial applicators.
    c. Miles or minutes of application at calibrated rate.

3. Control: Percent reduction related to:
    a. Larval or adult surveys or to both.
    b. Preselected Index sites sampled before and after application.
    c. Proper data reduction method for valid conclusions.

The above quality controls involve considerable ground work to establish the justification of treatment in the first place and to justify payment based on treatment effects when treatment is called for. The work is justified in that if the treatment is not needed, both money and environmental costs are avoided. Also when the application is needed the mosquito population will probably be high enough to show successful treatment when the application is made within the limits of the label and good professional judgement.

The monitoring of the applied product directly is possible but in general is beyond the resources of the community with the exception of larviciding granules.

1. Develop a contract containing performance standards.
2. Develop a sampling plan:
    a. to verify the necessity of an application.
    b. to time the application.
    c. to verify that control standards have been met.
3. Develop an informative announcement (leaflet) for the community including:
    a. The need for applications and the anticipated materials to be used.
    b. How treatments will be made and specifically where.
    c. Approximate times of application (time of day, possible days).
    d. Person to call for additional information.

Projects completed:

______________________	_____	(Signed) ______________________
______________________	_____	______________________
______________________	_____	______________________
project or report title	date	manager, teacher, leader, parent

Project II-D.7f Monitoring Weather Factors for Effective Application

Larvicides are applied by granules and large drops of about the same size (250 microns average diameter). Adulticides are applied as 50 micron droplets aerially and as 15 micron droplets from the ground from special ultra low volume (ULV) nozzles.

Larviciding operations are limited by winds over 12-15 mph and air temperatures over °F. The large particles fall readily to the target area.

The 50 micron droplets that weigh about 1/125 of a 250 micron droplet fall slower and are subject to additional restrictions. The wind should be between 3-10 mph, the air temperature below 82 °F, and no temperature inversion.

The ground ULV 15 micron droplets (the optimum size to hit a flying mosquito) have about 1/36 the volume of a 50 micron droplet and barely fall at all. For proper dispersion and residence time in the area the wind should be between 1-3 mph, the air temperature below °F, and with an inversion.

Larviciding is done during regular work hours. Aerial ULV adulticiding is done in early morning or late afternoon to avoid high temperatures and inversions. Ground ULV is done during the time of maximum flight activity of the pest species, usually from sunset to 2 hours after sunset when inversions occur under clear calm skys. Failure to observe the above weather factors as in scheduled routine adulticiding reduces the effectiveness of adulticiding operations to public relations events.

1. Use library references to find out the use of dry bulb (air temperature), wet bulb, and black bulb thermometers (both mosquitoes and droplets respond to humidity and the radiant temperature).
2. Use references to define and describe Wind Profile, Temperature Profile or Gradient, and Temperature Inversion within 50 ft of the ground.
3. Obtain a low speed wind gage or air meter. Always average several readings.
4. Detect inversion conditions by mounting 2 thermometers marked in 0.5 °C at about five feet and 15-20 feet. Allow time to stabilize.

$$\text{Stability Ratio} = \frac{\text{Top Thermometer - Bottom Thermometer}}{\text{Wind as (centimeters/second) squared}} \times 10^5$$

SR of 0.1 or greater = stable inversion for ground ULV
SR of -0.1 to 0.1 = neutral condition for aerial ULV
SR of -0.1 or less = unstable condition for no ULV application

5. Use daily weather data and maps from the nearest weather station to determine the average number of days or nights during a month proper conditions can be expected for adulticiding in your community.
6. What area can one ULV machine treat in an evening during optimum weather conditions if traveling 10 mph with one block (264-330 ft) swaths?
7. What area can a vector control aircraft treat in a day during optimum weather conditions in August traveling 150 mph with 300 ft swaths?

Projects completed:

(Signed)

project or report title   date   manager, teacher, leader, parent

Reference: Armstrong, J. A. 1979. Mosquito News 39(1):10-13.

Part III. Projects on Improving the Reliability of Control Operations

The more one knows about mosquitoes, the more often the best management strategy will be selected. Accurate knowledge is essential. Errors in observation and the lack of necessary observations are commonly occurring problems. For example, one indoor pesticide was about to be removed from the market as users complained it did not kill mosquitoes when used as directed. It did in the laboratory. It did not in the home. Unlike the lab mosquitoes, the wild species had "learned" to land on areas normally not treated and to avoid treated areas. A change on the container label of where to spray, related to the change in mosquito behavior, returned the product to its former effectiveness.

Not only is the mosquito an ever changing tricky pest, but it has an ally in the random force. It is impossible to make reliable predictions from a single count or observation because of the variation produced by the random force. You do not know where on the distribution of possible counts that a single count falls.

On the other hand, the random force can be trusted to play fair, to yield highly reproducible variations within any given set of conditions. The variation the random force produces can be used as a constant, as a standard, with which to compare the variation from assigned causes such as breeding site reduction, pesticide application, or a change in season. The sampling methods given in the research design projects should be made a part of all projects that involve counting and measuring. They save time and money by reducing errors of judgement.

Three ways of improving the reliability of control operation data are given. The quickest way is to use proper sampling and related data reduction for the interpretation of counts and measurements.

A. Know your research design projects show you how to control the variation in mosquito counts and measurement data and how to draw conclusions with a reasonable degree of reliability.

B. Know your mosquito habitat productivity limitation projects includes ways of studying the mosquitoes in your community at any time of the year.

C. Know your mosquito behavior projects introduces you to those imperfectly known factors to which mosquitoes react. Only your imagination is the limit in designing experiments and observations to aid in man's attempt to decode the microcomputer and its inputs contained within these little flying machines.

Proper research design with statistical control of the random force helps prevent self-deception. It provides an objective standard of reliability. Good research design and practical knowledge of your community are complements, not substitutes, for one another. Each alone can lead to disaster. It is a poor risk to fool yourself about Mother Nature.

Projects on Improving the Reliability of Control Operations

Table of Contents

Part III

A. Know Your Research Design for Reliable Data 77

- 1a. Examining the Nature of the Random Force in T-F Tests 78
- 1b. The Random Force and Experimental Design or How You Look at Things Determines What You See 79
- 2. Summing Up the Variation in a Sample 80
- 3. Interpreting the Variation and Establishing Confidence Limits . . 81
  - a. Using the Standard Deviation to Interpret Sample Variation . 82
  - b. Using the Standard Error to Establish Confidence Limits . . . 83
- 4. Significance Testing of Fixed Condition Effects 84
  - a. Summing the Variation for the ANOVA Table 85
  - b. Significance Testing for One Fixed Condition Effect 86
  - c. Significance Testing for Two Fixed Condition Effects 87
  - d. Significance Testing for Three Fixed Condition Effects . . . 88
  - e. Significance Testing Including Interaction of Factors 89
  - f. Expanding the Factorial Design 90

B. Know Your Mosquito Habitat Productivity Limits 91

- 1. Mosquito Habitat Field Observations 92
- 2. Mosquito Habitat Laboratory Observations 93
  - Figure 13. Examples of Cardboard Box Colony Chambers 94

C. Know Your Mosquito Behavior 95

- 1. Mosquito Behavior Field Observations 96
- 2. Mosquito Behavior Laboratory Observations 97

Reference:

Larkin, Jill, John McDermott, Dorothea P. Simon, and Herbert A. Simon. 20 June 1980. Expert and novice performance in solving physics problems. Science 208(4450):1335-1342.

An excellent discussion on the difference between a beginner and an experienced manager. There appears to be no substitute for actual experience and careful evaluation of what was learned by that experience.

III-A. Know Your Research Design for Reliable Data

Properly designed observations and counts not only provide reliable data and conclusions, but also save on time and expense. Projects III-A.4b-e show the relationship between the parts of efficient research designs:

a. The question you want to answer.
b. How you plan to get the answer including the fixed conditions imposed.
c. How you actually collected the data (rarely do things go completely as planned when making outdoor mosquito counts).
d. The calculation of the appropriate analysis of variance (ANOVA).
e. Drawing conclusions (answers to the question) that are consistent with steps b, c, and d without over or under stating the facts.

Projects III-A.1-3 develop an appreciation of the variation in samples including true-false and multiple choice tests.

Statistical tests are all designed around the null hypothesis, the idea that nothing of any significance happend unless the variation between fixed conditions exceeds a pre-selected limit. The limits are provided in tables that show the amount of variation expected from the random force alone without any other cause being involved. If the variation you calculate exceeds this value in the table then something other than the random force may have caused the difference.

When the null hypothesis is rejected and an alternate hypothesis is accepted, something other than the random force is now assumed to have caused the difference. That last statement sounds rather weak but is correct. The statistical test will tell you when to look for an alternate cause, but will not tell you what it is. The cause you have assumed, draining a breeding site, for example, may have made a significant reduction in the counts of mosquitoes at your light trap or it may have been the weather, the wind, a neighboring community's spray program, or the new street light installed near the trap. You must check these out by observation or by designing a new set of counts.

The main first value of a statistical test is to tell you when not to look for causes other than the random force. The tests help prevent you being tricked into believing there is a real difference between varying counts when in fact it is only due to the random force. Mosquito counts are highly variable. Without a proper research design including a statistical test, the counts can easily fool a person into believing there is a difference when in fact there is none. Fortunately the summation of the variation can be done with one calculation regardless of the test design.

To begin, verify the examples in the following projects. Once you have some familiarity with the calculations, your judgement will develop an appreciation of the relation between the various parts of a research design and the part calculating the variance plays in drawing valid, reliable conclusions. With practice in applying the following project research designs you will be able to make your own designs and to use more rigorous tables and suggestions from reference books in handling large data tables.

Project III-A.1a Examining the Nature of the Random Force in T-F Tests

Each time you take a true-false test, the random force, on the average, gives you half the answers. It will not tell you which specific ones are correct. Only on the average will it give you half the answers. At the same time, it is, individually, a deceiving tease and, collectively, a reliable standard.

Four students used coins to test the random force (chance it is sometimes called when it operates in simple cases) to pick the answers in a twenty question test.

Question	Correct	Individual Answers				Group Answers	
Number	Answer	Bill	Joan	Ralph	Mary	Pooled	New Toss
1.	T	F	F	Ⓣ	F	F	
2.	T	F	Ⓣ	F	F	F	
3.	T	Ⓣ	Ⓣ	F	Ⓣ	Ⓣ	
4.	T	Ⓣ	Ⓣ	F	Ⓣ	Ⓣ	
5.	T	Ⓣ	F	F	Ⓣ		Ⓣ
6.	T	Ⓣ	Ⓣ	Ⓣ	F	Ⓣ	
7.	T	F	F	F	Ⓣ	F	
8.	T	F	Ⓣ	Ⓣ	F		F
9.	F	T	Ⓕ	Ⓕ	T		T
10.	F	T	Ⓕ	Ⓕ	Ⓕ	Ⓕ	
11.	T	F	Ⓣ	F	Ⓣ		Ⓣ
12.	F	Ⓕ	Ⓕ	Ⓕ	Ⓕ	Ⓕ	
13.	F	T	Ⓕ	Ⓕ	T		T
14.	F	T	Ⓕ	T	T	T	
15.	T	Ⓣ	F	F	Ⓣ		Ⓣ
16.	F	T	T	Ⓕ	T	T	
17.	F	T	T	T	Ⓕ	T	
18.	F	T	T	T	Ⓕ	T	
19.	F	Ⓕ	Ⓕ	T	T		Ⓕ
20.	F	Ⓕ	T	T	T	T	
T:F Ratio	10:10	12:8	10:10	8:12	12:8	9:11	
Number Correct		⑧	⑫	⑧	⑩	⑨	

In this example from actual coin tosses, every test question was answered correctly by at least one of the four student's coins. No student could tell from their own answer sheet which answers were correct. The random force is a big tease. Even when they got together and pooled their coin results and tossed again to break ties, they neither got a better score nor did they know the correct answers.

The random force permits making general predictions (½ of the answers) but will not tell which is the correct answer for any one question. It is the nature of things that the privacy of an individual or individual event is to be protected from predictability. To make predictions you must take multiple count samples.

On your next true-false test use two answer sheets, one for the random force operating on a tossed coin and one for yourself. The difference between the two scores, doubled, is an indication of what you really know.

Project completed ________ (Signed) ______________________________
date manager, teacher, leader, parent

Project III-A.1b The Random Force and Experimental Design or How You Look at Things Determines What You See

The effects of the random force can also be observed in multiple choice tests in the case where you do not know the correct answer but you do know the incorrect answers. For each incorrect answer you identify, the odds of guessing the right answer improve. If you can identify all incorrect options, the remaining option must be the correct one. With 4-option questions, there are three incorrect answers, three choices, and three degrees of freedom.

Options You Know Are Incorrect	Choices Left	Degrees of Freedom	Odds of Guessing the Correct Answer	Improvement Over the Random Force
0	3	3	1/4	0%
1	2	2	1/3	33%
2	1	1	1/2	200%
3	0	0	1/1	400%

With a multiple choice test with fixed limits (4 options) the more options you know are wrong, the closer you are to the truth. In the real world the number of options is usually unknown. Trying things at random is generally not very productive. You just learn a lot of wrong answers.

An exception is the stocking of ponds with mosquito fish. One community found it impossible to predict in which ponds the fish would overwinter and provide good control of mosquitoes. They then stocked all ponds and let nature take its course. After stocking for three years the fish "reported" three types of ponds: those they can overwinter in with good mosquito control, those they cannot overwinter in but give good control when restocked from the overwintering ponds, and those they cannot live in or give poor control.

These people designed their three year experiment (control program) with the null hypothesis (the idea that what they did would make no difference) that the fish would not overwinter and control mosquitoes. In several ponds the null hypothesis had to be rejected as the fish did overwinter and control mosquitoes. The alternate hypothesis that the fish will overwinter and control mosquitoes is now acceptable for these ponds and overwintering conditions.

The above example is in contrast to the routine fogging done for adult mosquitoes as the only option for control. Each application gets one no closer to the correct answer. Even on days when a good kill occurs the breeding sites are still turning out more mosquitoes. In a few hours to a few days, the mosquitoes are biting as usual. The applicator wants to believe he is doing a good job even though he may not know or care to know the real facts. The best examples of this mental trap are the people who smoke in public. Because all seems well at the moment, does not mean they and those around them will escape the truth of its harmful effects.

It is fairly easy to design research to get the answers you want, as above for example, by using a very short observation period. Proper research design with statistical control of random force effects helps prevent self-deception, in believing in something you may not know or want to know.

Defend the position that Joan's coin that gave the correct answer 11 out of the first 14 tosses is of greater value than the other three coins.

Project completed ______ (Signed)______________________________
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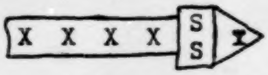
Project III-A.2 Summing Up the Variation in a Sample

One must first collect a number of mosquitoes to identify them. So it is with sample variation. One must first collect the variation numerically in order to use it either for making predictions or for determining if the difference between samples is due to an assigned cause or is just another result of the random force. Use either paper and pencil or a calculator.

The variation in a sample of multiple counts is described as the sum (Σ) of the squared deviations (d^2) of each count (X) from the sample mean ($\bar{X}$) or, for short, as the sum of squares (SS).

$$SS = \Sigma d^2 \qquad \text{or } SS = \Sigma(X - \bar{X})^2 \qquad \text{or } SS = \Sigma X^2 - \frac{(\Sigma X)^2}{n}$$

Two methods of summing the variation are given as a means for you to check your math as you learn the one calculation that will sum the variation for all ANOVA designs and the other projects. The following calculation guide for tabled data will keep the related counts (X), sums of squares (SS) and means ($\bar{X}$) together. The symbol means the sum of the squared deviations,



of the enclosed counts, from their mean. Worked examples are given below the instructions to show the comparison of the two methods.

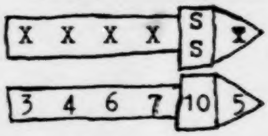
Paper and pencil method:

a. Add all the counts and divide by the number of counts (n) to obtain the average or mean ($\bar{X}$).
b. Square the difference (the deviation) between each count and the mean and add to obtain the sum of the squared deviations from the mean (SS).

Hand calculator method: (for large data and ANOVA tables)

a. Sum the square of each count.
b. Square the sum of all counts and divide by the number of counts.
c. Subtract the above two quantities to obtain the sum of squares (SS).

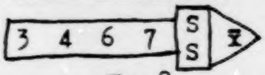
Paper and Pencil



$$\bar{X} = \frac{\Sigma X}{n} = \frac{3+4+6+7}{4} = \frac{20}{4} = 5$$

$$SS = \Sigma d^2 = 2^2 + 1^2 + 1^2 + 2^2 = 10$$

Hand Calculator



$$SS = \Sigma X^2 - \frac{(\Sigma X)^2}{n}$$

$$\begin{array}{ll} 9 & \\ 16 & \frac{(20)^2}{4} \\ 36 & \\ \underline{49} & \\ SS = 110 & - \ 100 = 10 \end{array}$$

1. Verify that the sample of mosquito counts of 18, 3, 11, 29, and 14 has a SS of 366 by both methods of calculation.

2. Sum the variation of your own data by both methods to check your math.

Project 1 completed ______ (Signed) ______________________

2 ______ ______________________

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III-A.3 Interpreting the Variation and Establishing Confidence Limits

The reliability of counts and measurements are estimated by comparing the actual results with those expected from the random force alone. When the two differ significantly, the actual results are assumed to be due to some cause, often a factor in or a fixed condition of your research design such as collecting at different sites or using alternate methods to reduce breeding.

There are many ways of making this comparison between the effects of assumed or assigned causes and the effects from the random force. When you make no assumptions, the variation in a sample of multiple counts can be summed and interpreted with the aid of the Standard Deviation of the sample (SD) and the Standard Error of the sample mean (SE).

The Standard Deviation (Project III-A.3a) needs no correction as the value is a characteristic of the variation of any sample size. The Standard Error of the sample mean (Project III-A.3b) is sensitive to sample size and must be corrected in calculating confidence limits if the number of counts (n) is less than 30.

Correction Factor (t) for Small Sample Size

Degrees of Freedom*	t value for 95% confidence limits
1	12.7
2	4.3
3	3.2
4	2.8
5	2.6
6	2.4
7	2.4
8	2.3
9	2.3
10	2.2
15	2.1
30	2.0
∞	2.0

* (n - 1) = Degrees of Freedom = °F

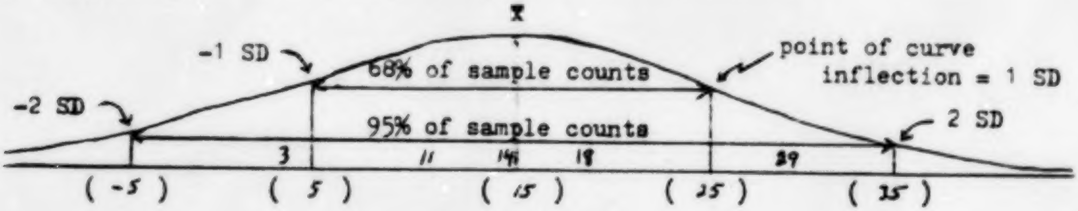
Good research design tries to reduce unnecessary variation and to obtain representative samples. A common practice in dipping for larvae is to record an average of several dips as the count for that site or the average of the 3 to 5 dips that contain at least one larva.

When the distribution of counts in a sample is far from a normal distribution, all counts can be "normalized" by a mathematical transformation as the first step in data reduction, before summing the variation. This procedure is not required in these projects, however, you will find it in some current scientific articles on mosquito populations.

Both the above "t" table and the following "F" table contain rounded values. For critical tests check references for more accurate values.

Project III-A.3a Using the Standard Deviation to Interpret Sample Variation

Mosquito counts and measurements often approach a numerical distribution called the normal curve. So do test grades. The curve represents a plot of a large number of counts from one population of counts.



The point of inflection on each side of the mean is called the Standard Deviation (SD). About 68% of the counts will fall in this range and 95% between twice this range. Making 100 mosquito counts, plotting them and drawing the curve is too time consuming a way of finding the SD. An easier way is to calculate the SD from a few samples.

a. First sum the variation (Project III-A.2).

b. Divide the SS by the number of counts (n) less 1 to obtain the variance or mean square (MS). (n - 1 = Degrees of Freedom in your sampling = ^{D}F)

MS or variance $= \frac{SS}{n-1} = \frac{366}{4} = 91.5$ SD $= \sqrt{\frac{SS}{n-1}} = \sqrt{\frac{366}{4}} = 9.5 \approx 10$

c. The square root of the variance is the Standard Deviation (SD).

d. Fill in your mean and the mean + and - one and two times the Standard Deviation below the scale line of the normal curve.

e. Plot the individual counts above the scale line by estimating locations.

Conclusions and Predictions:

a. The mean is a better estimate of the truth than each count.

b. Some 68% of similar (future) individual counts are expected to fall between the range of + and - 1 SD (5 to 25 mosquitoes per count).

Differences between samples can be detected by comparing their variances as the SD and as the Coefficient of Variation (CV). The CV is a relative variation: 100 x SD/$\bar{x}$. Counts of large numbers of mosquitoes tend to have large variances or SDs. The relative variances may be about equal for a large and a small sample. If both the SD and CV differ markedly, about double, look for a cause other than the random force.

1. Verify and plot on separate normal curve scale lines these two samples:
    a. Counts on a calm night:
       18, 3, 11, 29, 14 $\bar{x}$ = 15 SD = 9.5 CV = 63%
    b. Counts on a night with variable winds:
       34, 1, 2, 33, 5 $\bar{x}$ = 15 SD = 17.0 CV = 113%
2. Calculate the SD and plot your counts from a multiple count sample.

Project 1 completed _____ (Signed) ________________

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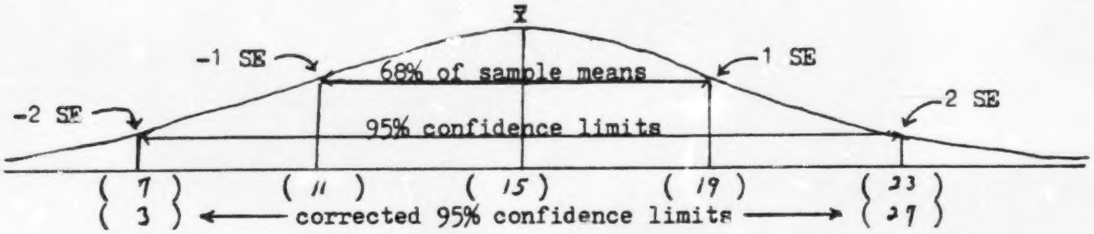
Project III-A.3b Using the Standard Error to Establish Confidence Limits

The means (averages) of mosquito counts and measurements approach the normal curve in the same manner as individual counts (Project III-A.3a). The distribution curve of sample means represents a plot of a large number of sample means. It can be calculated from one multiple count sample.



Finding the confidence limits for your sample mean:

a. Continue from the SD in project III-A.3a.

b. Divide the SD by the square root of the number of counts to obtain the Standard Error of the sample mean (SE).

$$SE = \frac{SD}{\sqrt{n}} = \frac{9.5}{\sqrt{5}} = 4.3 \qquad \text{or } SE = \sqrt{\frac{MS}{n}} = \sqrt{\frac{91.5}{5}} = 4.3 \approx 4$$

c. Fill in your mean and the mean + and - one and two times the Standard Error below the scale line of the normal curve. These values are for very large numbers of counts.

Correcting the Standard Error for small sample sizes:

a. Enter your mean, t value (from table), and your SE below:

mean		t		SE			
(15)	-	(2.8)	x	(4.3)	=	3	= lower 95% confidence limit
(15)	+	(2.8)	x	(4.3)	=	27	= upper 95% confidence limit

b. Carry out the calculations and enter the values below the scale line.

Conclusions and Predictions:

a. The corrected 95% confidence limits are as close to the truth as you can get with these data. To get closer requires more counts (increased sample size) or a more efficient research design which assigns part of the variance to specific causes as in the following projects of III-A.4.

b. Some 95% of other (future) sample means would be expected to fall within these limits if taken under the same conditions. Such means would not be considered significantly different from this sample.

1. Verify that the counts 18, 3, 11, 29, and 14 yield:

   SE = 4.3 95% Confidence Limits = 3 and 27

2. Calculate the SE and 95% Confidence Limits for your counts.

Project 1 completed _____ (Signed) ____________________

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III-A.4 Significance Testing of Fixed Condition Effects

When fixed conditions are a part of your research design, the variation from assumed or assigned causes and from the random force can be separated and compared by an appropriate analysis of variance (ANOVA) ending in an F test, a ratio of variances or mean squares (MS).

Table of Mean Square Ratios (F values) for the 95% Significance Level

Degrees of Freedom in the Denominator	Degrees of Freedom in the Numerator								
	1	2	3	4	5	6	12	24	∞
1	161	200	216	225	230	234	244	249	254
2	18	19	19	19	19	19	19	20	20
3	10	10	9	9	9	9	9	9	8
4	8	7	7	6	6	6	6	6	6
5	7	6	5	5	5	5	5	4	4
6	6	5	5	4	4	4	4	4	4
7	6	5	4	4	4	4	4	3	3
8	5	4	4	4	4	4	3	3	3
9	5	4	4	4	4	3	3	3	3
10	5	4	4	4	3	3	3	3	2
12	5	4	4	3	3	3	3	2	2
15	4	4	3	3	3	3	2	2	2
24	4	3	3	3	3	2	2	2	2
30	4	3	3	3	2	2	2	2	2
∞	4	3	3	2	2	2	2	2	1

Your F value is a ratio of the variance between that due to a presumed cause and that due to the random force. When your F value exceeds the value in the table, the null hypothesis (that idea that there is no difference) can be rejected. The alternate hypothesis, that there is a difference, can then be accepted. What is the actual cause of the difference between sample means must now be sought if it has not already been assigned as a fixed condition of the sampling.

Designing sampling methods that permit accurate assignment of the causes of variation is the fun of research design. There is no substitute for practice. Pick a design. Obtain your counts. Do the calculations. Consider how the design could be improved. With some experience you will discover the grand order and the multiple causes concealed within highly variable data such as mosquito counts and pesticide distribution subsamples.

CAUTION: The ANOVA must be selected as part of the research design, before collecting the data, otherwise you can fall into the self-deception trap of selecting an analysis such that the data will support a preconceived conclusion as well as possibly making biased observations in the first place.

Project III-A.4a Summing the Variation for the ANOVA Table

The symbol or calculation guide in project III-A.2 will sum the variation for any ANOVA table if the data are tabled such that:

a. All counts for one site (sample) are placed in one column.

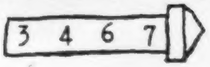
b. The counts are entered in the sequence they were made.

The SS of individual counts in the data table are obtained by the calculation in project III-A.2 which is repeated below. For the Total SS, include all counts in the data table.

$$\text{Total SS} = \Sigma X^2 - \frac{(\Sigma X)^2}{n} = \boxed{\text{Total}}$$

The SS of subtotals around the edge of the data table are obtained by first dividing each squared subtotal by the number of counts in the subtotal.

Individual Counts



$3^2 = 9$

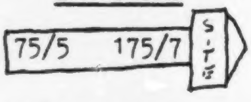
$4^2 = 16$ $\qquad \frac{(20)^2}{4}$

$6^2 = 36$

$7^2 = \underline{49}$

SS = 110 - 100 = 10

Subtotals



$\frac{(75)^2}{5} = 1125$ $\qquad \frac{(250)^2}{12}$

$\frac{(175)^2}{7} = \underline{4375}$

SS = 5500 - 5208 = 292

Calculate the SS in the sequence given in the ANOVA table. Subtract where indicated in the ANOVA table to obtain the remaining SS. Do the calculations twice as a check on your math. The within site (sample) SS can be summed as a better check when easily determined as in project III-A.4b.

1. Verify that 18, 3, 11, 29, and 14 yield a SS of 366
   26, 15, 22, 36, and 26 yield a SS of 232

2. Verify the SS of the following subtotals:
   44/2, 18/2, 33/2, 65/2, 40/2 yields 587
   66/5, 111/5, 86/5, 118/5, 119/5 yields 432

3. After working your way through the four sample projects (III-A.4b - e) insert your own mosquito counts or calibration data (Project II-D.7) into the factorial design with multiple interactions of three factors (Project III-A.4f) and solve. By this point you should be aware that the calculations take on a very repetitive rhythm that promotes fast accurate work.

Project 1 completed ______ (Signed) ______________________________

2 ______ ______________________________

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Project III-A.4b Significance Testing for One Fixed Condition Effect

Question: Is there a difference in the number of mosquitoes between two, or more, sites? (Site is the fixed condition.)

Conditions: Seven counts using the same method are to be made at two different sites. All other conditions are unspecified, random, and any other causes that may influence the counts are unknown.

Data Collection: At each site the counts were made as randomly as practical without introducing unnecessary known sources of variation. The more representative the counts are of the area, the better the data. All factors that may have influenced the counts were noted.

Data Reduction: Table the data and carry out the indicated calculations reviewed in projects III-A.2, 3, and 4a. Fill in the ANOVA table.

Five Minute Landing Counts

	Site A	Site B		Total
	18	26		
	3	15		
	skunk	18		
	11	22		
	29	36		
	lost	32		
	14	26		
ΣX =	75	175	SITES	250
n =	5	7		12
$\bar{X}$ =	15	25		20.8

ANOVA Table (completely randomized design)

Source of Variation	Degrees of Freedom	Sums of Squares	Mean Square	F Ratio
Total	11	988		
Between sites	1	292	292	4.2
Random force*	10	696	70	

* or Within sites

$SE = \sqrt{\frac{MS}{n}}$ $A = \sqrt{\frac{70}{5}} = \pm 3.7$ $B = \sqrt{\frac{70}{7}} = \pm 2.6$

The 95% confidence limits: (10 °F)

	($\bar{X}$	±	t	x	SE)	
A =	15	±	2.2	x	3.7	= 6.9 − 23.1
B =	25	±	2.2	x	2.6	= 19.3 − 30.7

Conclusions and Observations:

a. The F value is based on a ratio of 1/10 degrees of freedom. In the table of F values, 5 is given for this ratio. The two means of 15 and 25 are not significantly different as the calculated F ratio (4.2) is less than 5. The null hypothesis of no difference stands, must be accepted.

b. The 95% confidence limits overlap, which also indicates the two samples are drawn from the same population of mosquito counts, a population with a mean of 21. (Even if the confidence limits did not overlap, the F test takes precedence. In general, the test with the largest number of degrees of freedom takes precedence.)

c. During the counting periods, the number of mosquitoes landing seemed to be related to the amount of wind. This possible cause of variation can be isolated by designing a new experiment (Project III-A.4c).

To compare more sites at one time, expand the data table by adding sites C, D, E, etc., summing the variance as above, and adjusting the degrees of freedom in the ANOVA table. A multiple range test using the table of "q" will give a better separation of multiple samples than confidence limits if needed.

1. Verify the calculations in the example or use your own data.
2. Verify Within sites SS (696) is the sum of SS within A (366) & B (330).

Project 1 completed ______ (Signed) ______________________

2 ______ ______________________

date manager, teacher, leader, parent

Project III-A.4c Significance Testing for Two Fixed Condition Effects

Question: Is there a difference in the number of mosquitoes between two (or more) sites?

Conditions: Six counts using the same method are to be made:
1. at two different sites and
2. at the same time at each site (under the same wind conditions).

All other conditions are as stated in project III-A.4b.

Data Collection: As in III-A.4b except both site and time are fixed.

Data Reduction: Table the data and carry out the indicated calculations reviewed in projects III-A.2, 3, and 4a. Fill in the ANOVA table. Any lost data requires discarding the entire time block.

Five Minute Landing Counts

Time Blocks	Site A	Site B	$\Sigma X/n$
1	18	26	44/2
2	3	15	18/2
3	11	22	33/2
4	29	36	65/2
5	14	26	40/2
6	~~15~~	lost	TIMES
ΣX =	75	125	SITES 200
n =	5	5	10
$\bar{X}$ =	15	25	20

ANOVA table (randomized block design)

Source of Variation	Degrees of Freedom	Sums of Squares	Mean Square	F Ratio
Total	9	848		
Between times	4	587	147	52
Within times	(5)	(261)		
Between sites	1	250	250	89
Random force*	4	11	2.8	

*or within sites - between times: 598-587 = 11

$$SE = \sqrt{\frac{MS}{n}} = \sqrt{\frac{2.8}{5}} = \pm 0.75$$

The 95% confidence limits: (4 °F), ($\bar{X} \pm t \times SE$)

A = 15 ± 2.8 × 0.75 = 12.9 – 17.1

B = 25 ± 2.8 × 0.75 = 22.9 – 27.1

Conclusions and Observations:

a. The F values based on ratios of 1/4 and 4/4 degrees of freedom are both far larger than the F table values of 8 and 6. The null hypothesis of no difference must be rejected. The two means for sites A and B are significantly different. Why the sites are different must now be sought.

b. The 95% confidence limits do not overlap. Each site represents a different population of mosquito counts.

c. By blocking time, the variation due to wind conditions was statistically isolated or controlled. Had this not been a part of the research design, the results from this set of counts would have been the same as in III-A.4b where time was at random, subject to the random force. Wind conditions had a significant effect on the counts.

d. Two people were required to make the counts at the same time. Were the sites different because of the mosquitoes or because of the people doing the counting? (Project III-A.4d)

Verify the calculations in this example or use your own data.

Project completed ______ (Signed) ______________________
date manager, teacher, leader, parent

Project III-A.4d Significance Testing for Three Fixed Condition Effects

Question: Is the difference between two sites due to the mosquitoes or due to the people making the counts?

Conditions: Five counts are to be made using the same method:
1. at five different sites in rotation
2. by five different people (A, B, C, D, E) and
3. during the same five time periods (weather conditions).

Data Collection: As in III-A.4b except for the fixed conditions.

Data Reduction: Table the data and carry out the indicated calculations. If a count is missed, the entire experiment should be repeated.

Five Minute Landing Counts

Time Blocks	Sites						$\Sigma X/n$
	1	2	3	4	5		
1	A 10	B 25	C 18	D 24	E 26		103/5
2	E 0	A 9	B 8	C 20	D 10		47/5
3	D 12	E 20	A 10	B 20	C 27		89/5
4	C 29	D 37	E 33	A 32	B 42		173/5
5	B 15	C 20	D 17	E 22	A 14		88/5
							TIMES
ΣX =	66	111	86	118	119	SITES	500
n =	5	5	5	5	5		25
$\bar{X}$ =	13.2	22.2	17.2	23.6	23.8		20
Person =	A	B	C	D	E	PEOPLE	
ΣX =	75	110	114	100	101		
$\bar{X}$ =	15	22	22.8	20	20.2		

ANOVA Table (5 x 5 Latin Square design)

Source of Variation	Degrees of Freedom	Sums of Squares	Mean Square	F Ratio
Total	24	2,400		
Between times	4	1,682		
Within times	(20)	(718)		
Between sites	4	432	108	12.7
Between people	4	184	46	5.4
Random force	12	102	8.5	

$$SE = \sqrt{\frac{MS}{n}} = \sqrt{\frac{8.5}{5}} = 1.3$$

The 95% confidence limits
(12 °F),($\bar{X}$ ± t x SE)

$$\bar{x} \pm 2.2 \times 1.3$$

$$\bar{x} \pm 2.9 \approx 3$$

Conclusions:

a. There is a significant difference in the mosquito counts between sites and between people based on the F tests. Those samples with overlaping 95% confidence limits are not significantly different:

SITES				
1	3	2	4	5
13	17	22	24	24
10-16	14-20	19-25	21-27	21-27

PEOPLE				
A	D	E	B	C
15	20	20	22	23
12-18	17-23	17-23	19-25	20-26

b. Site 1 has significantly lower mosquitoe counts than sites 2, 4, and 5.

c. Person A obtained significantly fewer mosouitoes than C. Why?

d. The difference in mosquito counts between two sites may be assigned to either mosquitoes or people unless a research design is used to control (separate) the variation from each (including the weather in this case).

Verify the calculations in the example or use your own data.

Project completed ______ (Signed) ______________________
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Project III-A.4e Significance Testing Including Interaction of Factors

Question: Has reduced breeding in the main source area made a significant reduction in biting mosquitoes in the community?

Conditions: Three index sites were established to monitor biting mosquitoes in the community prior to source reduction work.

Data Collection: Weekly counts were made during each biting season.

Data Reduction: Table the data and carry out the indicated calculations. Check references for instructions for estimating missing counts.

Weekly Average Counts or Light Trap Collections

Week	Site:	1		2		3			$\Sigma X/n$
Blocks	Year:	78	79	78	79	78	79		
1		26	10	18	10	8	9		81/6
2		10	0	8	9	7	3		37/6
3		27	12	10	10	7	9		75/6
4		45	29	33	32	10	12		161/6
5		14	15	17	14	7	5		72/6
6		9	4	3	3	2	3		24/6
7		14	10	11	11	3	4		53/6
8		5	5	6	5	2	2		25/6
									WEEKS
ΣX =		150	85	106	94	46	47	SAMPLES	528
n =		8	8	8	8	8	8		48
$\bar{x}$ =		18.8	10.6	13.2	11.8	5.8	5.9		11

Site =	1	2	3	SITES
$\Sigma X/n$ =	235/16	200/16	93/16	
$\bar{x}$ =	14.7	12.5	5.8	

Year =	1978	1979	YEARS
$\Sigma X/n$ =	302/24	226/24	
$\bar{x}$ =	12.6	9.4	

ANOVA Table (factorial design)

Source of Variation	Degrees of Freedom		Sums of Squares		Mean Square	F Ratio
Total	47		4056			
Between weeks	7		2304			
Within weeks	(40)		(1752)			
Between samples	5		957		(191)*	(8.4)
Between sites		2		684	342	15.1
Between years		1		120	120	5.3
Sites x years		2		153	76	3.3
Random force	35		795		22.7	

* if not significant, do not make F test of partitioned MS

Samples SE = $\sqrt{\frac{MS}{n}}$ $\sqrt{\frac{22.7}{8}} = 1.7$

Sites SE = $\sqrt{\frac{22.7}{16}} = 1.2$

Years SE = $\sqrt{\frac{22.7}{24}} = 0.97$

The 95% confidence limits (35 °F), ($\bar{x} \pm 2 \times SE$)

Conclusions:

a. There is a significant reduction in mosquitoes from 1978 to 1979.

b. The F ratio for the interaction of sites by years indicates the reduction has not been uniform for the three sites.

c. The 95% Confidence Limits (CL) for sample means indicate a significant reduction only at site #1 near the managed main breeding source area.

d. The 95% CL for site means show site #3 having significantly fewer counts.

Verify the calculations in the example or use your own data.

Project completed ______ (Signed) ______________________
date manager, teacher, leader, parent

III-A.4f Expanding the Factorial Design

The factorial design is one of the most flexible and useful designs for both outdoor data and for laboratory data. The data table can be expanded vertically by adding more fixed conditions or factors and horizontally by adding more replications and duplications of these factors. Only those factors and interactions needed to answer your questions need be calculated. The remaining interactions can be ignored or their SS and °F left with the random force, for example, between rows (weeks) is often not needed.

The community in project III-A.4e could have elected to set up index sites in both their control area and outside the control area, a reference area. The data table and the ANOVA table would then appear as given below.

Data Table for Mosquito Counts

Weeks	Area:	Control		Reference		
	Year:	1978	1979	1978	1979	
1		X	X	X	X	
2		X	X	X	X	W
3		X	X	X	X	E
4		X	X	X	X	E
5		X	X	X	X	K
6		X	X	X	X	S
7		X	X	X	X	
8		X	X	X	X	

SAMPLES	1, 2, 3, 4	°F = 3
AREAS	1 + 2, 3 + 4	°F = 1
YEARS	1 + 3, 2 + 4	°F = 1

Partial ANOVA Table

Source of Variation	Degrees of Freedom	°F in F test
Total	31	
Between weeks	7	(7/21)
Within weeks	(24)	
Between samples*	3	(3/21)
Between areas	1	1/21
Between years	1	1/21
Areas x years	1	1/21
Random force	21	

* or sum Areas by Years

The community could have used control and reference areas with three replications (sites) in each area as they duplicated (years) the observations.

Data Table for Mosquito Counts

	Area:	Control						Reference						
Week	Site:	1		2		3		1		2		3		
	Year:	8	9	8	9	8	9	8	9	8	9	8	9	
1		X	X	X	X	X	X	X	X	X	X	X	X	
2		X	X	X	X	X	X	X	X	X	X	X	X	W
3		X	X	X	X	X	X	X	X	X	X	X	X	E
4		X	X	X	X	X	X	X	X	X	X	X	X	E
5		X	X	X	X	X	X	X	X	X	X	X	X	K
6		X	X	X	X	X	X	X	X	X	X	X	X	S
7		X	X	X	X	X	X	X	X	X	X	X	X	
8		X	X	X	X	X	X	X	X	X	X	X	X	
		(1	2	3	4	5	6	7	8	9	10	11	12)	

SAMPLES	1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 11, 12	°F = 11							
AREAS	1-6, 7-12	°F = 1							
SITES	1+2+7+8, 3+4+9+10, 5+6+11+12	°F = 2							
YEARS	1+3+5+7+9+11, 2+4+6+8+10+12	°F = 1							
Sum A by S	1+2, 3+4, 5+6, 7+8, 9+10, 11+12	°F = 5	−	AREA	−	SITE	=	Area x site	
Sum A by Y	1+3+5, 2+4+6, 7+9+11, 8+10+12	°F = 3	−	AREA	−	YEAR	=	Area x year	
Sum S by Y	1+7, 2+8, 3+9, 4+10, 5+11, 6+12	°F = 5	−	SITE	−	YEAR	=	Site x year	

Partial ANOVA Table

Source of Variation	Degrees of Freedom	°F in F test
Total	95	
Between weeks	7	(7/77)
Within weeks	(88)	
Between samples*	11	(11/77)
Between areas	1	1/77
Between sites	2	2/77
Between years	1	1/77
Areas x sites	2	2/77
Areas x years	1	1/77
Sites x years	2	2/77
A x S x Y	2	2/77
Random force	77	

* or sum Areas by Sites by Years

In general, keep your designs as simple as possible. If you do need to relate a large number of factors, replications, or duplications, diagram your data table and ANOVA table as above to account for all degrees of freedom.

See project III-A.4a for project instructions.

III-B Know Your Mosquito Habitat Productivity Limits

Each mosquito habitat has a limit from zero to some maximum number of mosquitoes it can produce. This limit varies with weather patterns and the season of the year. All habitats can be classified by the types of mosquitoes they produce and by the regularity of that production:

a. every year
b. only on years with abnormal weather or flooding and
c. never produce pest species (there may be other species of mosquitoes living there).

Mosquito district managers learn the location and productivity of the main breeding sources in their districts. By proper management of water, habitat modification, and larvaciding they can reduce production to below the community threshold level for complaints or below the level that disease transmission is likely to occur.

Mosquito managers rarely have the time to find out why two sites that look very much alike will produce different numbers and at times different species of pest mosquitoes. The number of possible factors is too large for the time they have available.

The riddle of the "identical ponds" with different mosquito productivity is one of the natural experiments waiting for a skilled observer to solve. There has to be something different about them. There are two ways of solving the riddle: by field observation and by laboratory simulation.

Nature dictates when field observations must be made. If you are not there when an event occurs, you miss it. Laboratory simulation can start at any time _if_ you can provide the minimum conditions for the species to develop. Ideally these conditions would permit rearing the species for several generations. This is not needed if you can bring in samples from the field as needed.

The solution to the "identical pond" riddle is important as it just may lead to a better practical control option in your community. In the process you will learn much more about the environment and how different organisms, both plant and animal, the weather, and soil interact to limit the production of the pest and non-pest species.

You will need to have on hand or in the library books for the identification of insects, birds, plants, and animals that live in the water and on land within mosquito habitats. In this case the habitat has two different parts: larval and adult. Any break in the life cycle such as a lack of suitable water or of a host for a blood meal will limit the production of mosquitoes.

Reference:

Special Report: Mosquito Research. March 1980. California Agriculture, Volume 34, Number 3. 44 pages. Single copies free. (California Agriculture, 317 University Hall, 2200 University Avenue, Berkeley, CA 94720, Telephone (415) 642-7252.)

Project III-B.1 Mosquito Habitat Field Observations

Factors to consider in comparing two habitats:

a. Water quality: temperature, depth and variation, color, opacity, pH, salinity, dissolved material, organic matter

b. Weather: wind direction, velocity, air temperature, relative humidity

c. Surface margin: protection, vegetation, wave action, sunlight exposure

d. Plant growth: in pond, at margin (algae to vascular plants) and on shore (adult roosting sites)

e. Animals: in water and on shore (protozoa to mammals)
predators, parasites and competing species of mosquitoes
the animals that serve as hosts for blood meals

f. Soil: type, permeability and temperature

g. Water: source and drainage, duration

Project suggestions:

1. After locating your two "identical" sites, select the factors you can work with. Compare each factor for the two sites. Record all observations. Don't trust to memory.

2. Determine how small an area or volume of the site would be needed to maintain similar conditions in a laboratory aquarium or cage. Hold part of the larvae in an emergence trap (a container with the top and bottom removed, pressed into the mud and covered with mesh to confine emerging adults). Transfer part of the larvae to an aquarium or glass jar. Record the rate of development of the larvae, pupae, and adults and the relative survival of each life stage. Explain the differences between the indoor and outdoor samples.

   Each explanation is a tentative hypothesis, a possible answer, to the question raised by the difference observed. Experiments can be designed to determine which hypotheses must be rejected and which are acceptable using additional field collections of larvae.

3. Find the overwintering sites for your pest species that overwinter
   a. as adults
   b. as eggs
   c. as larvae or pupae

4. Determine the species of animals used as hosts for blood meals:
   a. their number per unit area (mice per 100 ft^2, cattle per acre)
   b. the time of year available as hosts
   c. the age preferred by the female mosquito (baby birds, old frogs)

5. Find the day time adult roosting sites for your pest species.

Projects completed:

______________________ ______ (Signed) ______________________

______________________ ______ ______________________

project or report title manager, teacher, leader, parent

Project III-B.2 Mosquito Habitat Laboratory Observations

Laboratory observations can be made at several levels of complexity.

1. Glass jar or pan aquarium (for collected larvae and pupae)

Dip larvae and pupae from productive sites (use a tube and suction bulb for tree holes). Hold in the water in which found with about the same depth. Include samples of other organisms living with them. Observe their interactions after they have had time to settle down. Hold until the adults have emerged. Add dechlorinated water or more pond water if needed.

2. Plastic milk carton for overwintering eggs (any time of year)

Cut all vegetation off the sample area. Cut soil samples about one inch thick that fit in the bottom 2/3 of a gallon milk carton. Cover with about 4 inches of chlorine free water. Keep at room temperature. Remove scum as needed or include some snails. Transfer pupae to clean water for the adults to emerge or put sample in a colony chamber (below). Take soil samples from areas that will be flooded in spring but only moist thereafter.

3. Colony chamber (for continuous rearing)

Factors to satisfy	Simple means (Figure 13)
a. Enclosure	Cardboard box with one side covered with Saran wrap or other clear plastic
b. Entrance	Cloth sleeve or tin can sleeve with snap cap
c. Egg laying and larval breeding sites	Plastic butter tub lined with paper towel held in gallon jar resting on its side
d. Feeding: larvae	Small amounts of dry grass, leaves, yeast, crumbled dog biscuit. Light and the avoidance of overfeeding will prevent molds.
adults	Sugar cubes, boiled raisons, host blood. Place in chamber or on top of mesh covering a space on the top of the chamber.
e. Adult roosting (artifical canary grass)	Hang a bundle of paper towel strips from the top of the box with part of the strips emersed in a dish of water.
f. Emergency water for adults	A tall container of water that will evaporate slower than other pools in the box.
g. Water level in larval breeding site	Eggs laid by Aedes on moist paper towel will hatch each time the tub is refilled.
h. Mating	Requires a large box, release into a small room and then recapture, or artifical mating.

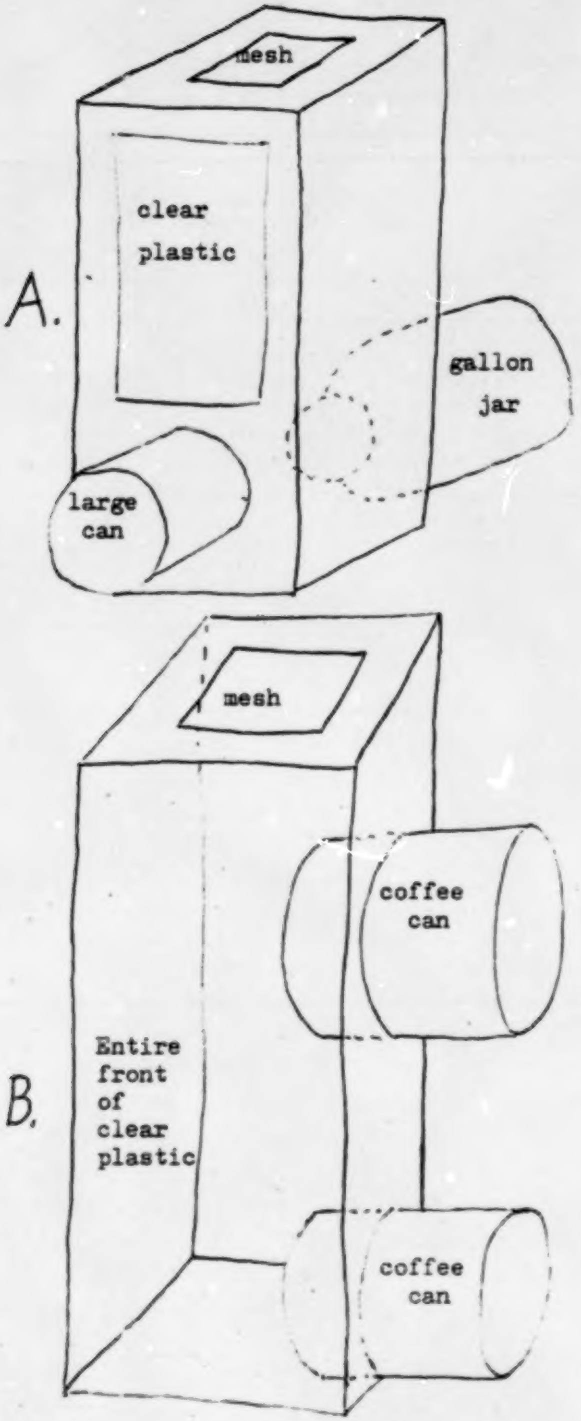
Vary conditions to match the needs of each species. Only a few have nearly the same requirements. They will be found living together at times. When you have duplicated the outdoor conditions, you will have continuous rearing.

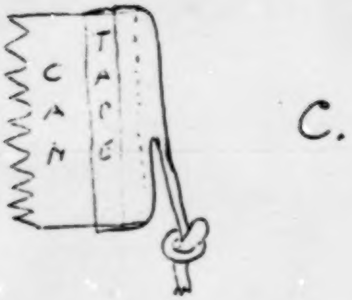
Projects completed:

______________________ ______ (Signed) ______________________

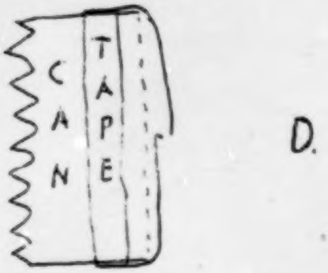
______________________ ______ ______________________

project or report title date manager, teacher, leader, parent


mesh
clear plastic
A.
gallon jar
large can
mesh
coffee can
B.
Entire front of clear plastic
coffee can



Cut the long sleeve long enough to tie in a knot or to secure with a rubber band.



Cut the short sleeve (of mesh) just long enough to hang closed and then secure with the plastic snap cap can cover.

Cut holes for jars and cans a bit smaller than the container and then force fit (with turning) for a mosquito tight union.

Combine jars, cans and boxes as needed. Restrict ventilation as a high relative humidity, in relation to normal room air, is required.

The two colony chambers overwintered Aedes and Culiseta. The Aedes had a new batch of adults each month after the almost dry egg tub was reflooded in the gallon jar.

Figure 13. Examples of cardboard box colony chambers and entrances. A. Aedes colony; B. Culiseta colony; C. entrance can with long sleeve; D. entrance can with short sleeve, secured with plastic snap cap.

III-C. Know Your Mosquito Behavior

Each mosquito has a preprogramed brain. This program is typically fixed like that of a hand calculator. Each mosquito's ability to learn is very limited. Through environmental selection or laboratory selection a species can "learn" new behavior in a few generations.

The preprogramed behavior of a species directs the adult female to nectar and blood feeding sites, day time roosting sites, mating sites, and egg laying sites. The input sensors are known to respond to temperature, relative humidity, light (both color from UV to Infrared and brightness), touch, taste, odor, carbon dioxide, movement, sound, wind, and acceleration (relative wind velocity).

Decoding the program has practical implications as well as the fun of solving the puzzle. In the field, observations can be made of the conditions related to a particular behavior or a modification of the environment can be made to observe for a change in behavior. The change in behavior exhibited by mosquitoes at increasing distances up or down an arm or leg from the site of a repellent application is a good example. Are there other ways the program can be tricked so the mosquito will have its reproductive potential reduced, such as, searching for the wrong host, in the wrong place, or laying eggs in the wrong breeding site?

In the laboratory, well defined conditions can be set up and altered to see the change in behavior. Since mosquitoes can sense and respond to stimuli people cannot, great care is needed to produce valid results with relatively simple equipment. Larvae and pupae as well as adults exhibit characteristic stimuli responses and behavioral sequences.

A behavioral sequence is made up of the small individual steps (separate acts or responses) that are carried out each time the stimulus is present. Individual nerve impulses and muscle contractions to the more easily observed movement of legs, wings, and other body parts can be monitored. The stimulus can be either internal (hunger) or external (a shadow). Whatever you change in the environment that produces a repetition of a behavioral sequence must be the stimulus or be directly related to it.

Behavioral studies can be carried out with minimal equipment and references when describing the behavioral sequences of your pest species. When the time comes to explain the behavioral sequence or to control or alter it, make use of all available reference literature. Read it with healthy skepticism as a source of ideas and procedures you can check out on your pest species.

CAUTION: Don't overwork your subjects. Give them time to return to "normal" before the next test. In the field some larvae may require up to a half hour before they will return to active feeding and breathing at the surface. Use field observations as guides for timing laboratory experiments.

The following projects contain lists of behavioral sequences that can be observed in your pest species. Determine the individual steps and the time required for each. What must the mosquito "know" and do to exhibit the observed behavior? What would you have to tell it to do (if you were in control) for it to exhibit this behavior? What change in behavior occurs when you change a habitat factor (Project III-B.1)?

Project III-C.1 Mosquito Behavior Field Observations

Behavioral sequences, niches and habitats:

Larva: (each instar) How it hides, feeds, breaths, maintains station, avoids predators. (Determine the part of the habitat that can be taken to the laboratory for closer study of the niche.)

Pupa: Timing of adult emergence and as above except for feeding.

Adult: Emergence to flight, first nectar feeding, daytime roosting, mating, egg laying and site selection (artifical egg stations: boxes, tires, containers, surfaces that match or exceed standards in nature).
Host selection (baited stations for collecting).
Flight patterns for host detection, location and approach (repellents, perfumes, clothing types and colors).
Flight initiation, cessation, and orientation.
(Be alert to conditions that can be simulated in the laboratory)

Each of the above behavioral sequences provides material for a study of the mosquito's adaptation to its environment. Two behavioral sequences are of great practical importance in mosquito management: flight activity and egg laying. These are used as indicators of the number of mosquitoes in the community. Properly located sites are known as Index or Reference stations and are maintained over a period of years. Their value is that, if representative of the community, one or two stations will provide as much useful information as a dozen set out completely at random.

Flight activity is usually measured by light traps, landing counts or landing-biting counts, and baited traps. Artifical egg stations are used to measure egg laying as an indication of the number of females that have not only survived to feed but to also develop eggs. Much work remains in devising egging stations that will match or exceed the attractiveness of natural sites. These stations are also a supply of eggs and larvae for laboratory studies that do not require having to enter onto private property or other possibly hazardous areas.

1. Behavioral sequence projects: Select the behavior and then describe it in as many steps (as fully as) possible. Relate the steps to the environmental factors that turn the sequence on, sustain it, and turn it off. That is, find the limits in which the behavior occurs.
2. Index station projects: Select the type of station and then observe the conditions under which females visit it. Observe the effects of changes in the station such as light intensity for light traps, different types of clothing for landing counts, or different pollutants or larval foods in the water of egging stations.
3. Locating Index stations: Select a number of sites that may be representative of the entire community or major parts of it. Determine the location and how few stations are needed for establishing Index or Reference stations in control and reference areas.

Projects completed:

		(Signed)
project or report title	date	manager, teacher, leader, parent

Project III-C.2 Mosquito Behavior Laboratory Observations

Behavioral sequences, niches, and stimulus responses:

Egg: Storage time and conditions, hatching conditions, effect of freezing.

Larva and Pupa: Combinations of factors in III-B.1 and III-C.1.
Survival rates for artifical wave action, rain, and flow.
Effects of water depth, oil, and insecticides.

Adult: Combinations of factors in III-B.1 and III-C.1 but carried out in a contained and controlled environment.
Flight mills, flight courses and selection or choice tests.

Laboratory study of mosquito behavior has a severe limitation that must be kept in mind when interpreting results: With a few exceptions mosquitoes spend nearly 100% of their time in the outdoors under varying conditions that have little relation to the uniform, and often highly polluted, indoors.

To begin your studies use freshly collected mosquitoes of the stage of interest or the next younger stage and hold for the desired stage. Eggs, larvae and pupae are easy to work with. Keep them cool when collecting them.

You can describe adult mosquito behavior by making observations in a simple colony chamber or releasing a few in a cleared room. Light, relative humidity and temperature are the easiest to change to observe related behavior. Indoors, many species will demonstrate fright reactions for an extended period. Try a screened room or large screen sided tent.

Decoding adult behavior in indoor facilities requires carefully designed experiments and equipment. Consult basic references in insect behavior and mosquito behavior.

For behavior projects, and other projects that require extensive planning, divide the work into subprojects. The following divisions are traditional in research work. Each builds upon the preceding project.

1. Your question, project proposal and literature review
2. Methods and materials, equipment assembled
3. Data gathered and data reduction
4. Final report, conclusions and recommendations for further study

Further divisions are useful in assigning work to several people. The first three subprojects can be divided into the tasks of:

a. Writing a researchable question
b. Specifying ways to obtain the answer and possible answers
c. Obtaining reference information on the question and the answers
d. Specifying data or observations needed to answer the question
e. Specifying exact details of methods and materials for the selected research design
f. Selecting the proper statistical test for the research design

Projects Completed:

		(Signed)
project or report title	date	manager, teacher, leader, parent

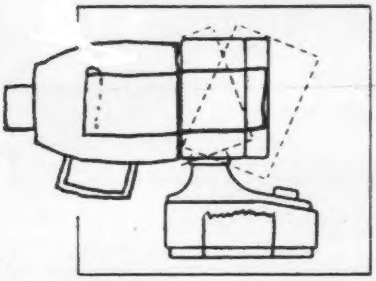
Addendum

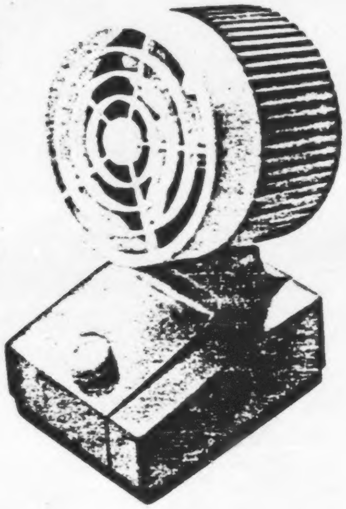
The following unit has recently been marketed by several mail order firms. It has the power to draw mosquitoes into a collecting capsule. The price is less than the cost of building a fan unit yourself as it comes with a battery case and switch. Mount the collecting capsule with two duct tape tabs. Secure the battery case with a piece of duct tape to prevent opening during operation. This unit matches the size of the collecting capsule. Avoid units with square housings.

Porta-Fan

Only \$3$^{\underline{99}}$

2 for $6.99
3 for $9.99
plus postage





Available from: Nora Nelson, Dept DJ
621 Avenue of Americas
New York, NY 10011
Trade Name: Mini Fan

Sterling House, Dept PF-201
Sterling Building
Garnerville, NY 10923
Trade Name: Porta-Fan